# ENGINEERING NEWS
AND
## AMERICAN RAILWAY JOURNAL.

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THE BROOKLYN WATER SUPPLY has recently been the subject of complaint on account of objectionable taste and odor. A report by Prof. A. R. Leeds, of Stevens' Institute, states that the taste and odor are due to the decomposition of vegetable organisms in the water; which though objectionable are not harmful or dangerous. Mr. I. M. De Varona, Chief Engineer of the Brooklyn Water-Works, in transmitting Mr. Leeds' report, calls attention to the need of laboratories equipped for systematic chemical and biological examinations of the water supply. He has recommended the establishment of such laboratories in his last two annual reports, and believes that the present trouble could have been avoided had such laboratories been in operation. The widespread complaints respecting the quality of the water, however, have resulted in appropriations for needed work in the water department. On Sept. 18 the aldermen appropriated $150,000 for diverting Horse Brook, a polluted stream, which now enters one of the reservoirs, $75,000 for buying and cleaning ponds not now owned by the city, and $311,555 for current expenses, included in which is $45,000 for cleaning ponds and reservoirs now owned by the city.

We note that in the debate over appropriations one of the aldermen expressed his conviction that some of the bad taste of the water was due "to the effect on the water mains of waste electricity from the trolley wires!"

MILWAUKEE'S WATER SUPPLY has been assailed as to its quality by Dr. Kemster, the City Health Commissioner, who declared in a report dated Sept. 12 that the water had been contaminated by sewage from the city and by the dumping of garbage into the lake. Analyses of the water, however, by Prof. Victor C. Vaughn, of the Michigan University; Prof. E. G. Smith, of Beloit College, and A. S. Mitchell, State Chemist of Wisconsin, all show that the water is pure and wholesome.

THE WATER SUPPLY TO JERSEY CITY, which has been furnished by the East Jersey Water Co. since April 12, is now the subject of controversy as respects payment. The company claims that the city is bound to pay for all the water it has received the full price of $43 per million gallons. The city officials hold that as the company did not furnish the full supply on April 12, which it agreed to furnish, the city is not bound to pay the full contract price per million gallons for the partial supply it has received. It has not been able to shut down its Belleville pumping station as it would have done had the full supply been furnished, and as it has not been able to make this saving it should not be compelled to pay the full price for the partial supply.

IMPURITIES IN CHICAGO'S WATER SUPPLY are claimed to have caused the death of over 3,000 infants and young children during the past twelve months. The Chicago Health Department has made a careful study of the subject of infant mortality and has concluded that the efforts which the department has made to secure a pure milk supply will avail little to secure a decrease in infant mortality till the quality of the water supply is improved. The Chicago "Record" quotes as follows from the department's report for August:

It is not unreasonable to infer that if the Chicago water supply had been as good during the last twelve months as the Chicago milk supply, the death of infants and young children, instead of aggregating nearly 10,000 during the period, would not exceed two-thirds that number, which implies an avoidable loss of more than 3,000 lives in this age period alone.

Besides infantile diseases, typhoid is increasing of late. In the first 21 days of September there were 64 deaths from this disease; and there are said to be over 600 cases in the city.

WATER METERS have scored a great success in Atlantic City this year. At the beginning of the year about 350 were in use. The city appropriated $25,000 for the purchase of additional meters, and 1,520 additional meters have been put in service since that time, so that 70 of the consumers now take water through meters. The result has been a decrease in water consumption of nearly 20%, the average daily consumption for August, 1896, having been 6,285,460 gallons, against 7,726,000 gallons in August, 1895. The laying of an additional supply main across the meadows, which was deemed necessary some time ago, has been indefinitely postponed by the decreased consumption due to the use of meters.

BIDS FOR SIX LARGE PUMPING ENGINES are asked in our advertising columns by the city of Chicago. Each engine will be of the vertical condensing triple-expansion type and capable of pumping 20,000,000 gallons of water per 24 hours, with a total lift of 150 ft. Three of the pumping engines will be installed at the new pumping station to be built at the corner of Central Park Ave. and Fillmore St., and the other three at the new station to be built at Springfield Ave. and Bloomingdale Road. Mr. Joseph Downey is the Commissioner of Public Works.

AN ENGLISH TANK LOCOMOTIVE built for the Wirral Railway has twelve wheels, of which only four are driving wheels, there being a leading and a trailing four-wheel truck. The engine has side tanks and a rear coal bunker, and its general dimensions are as follows:

| | |
|---|---|
| Driving wheels (4) | 5 ft. 2 ins. |
| Truck wheels (8) | 3 " 0 " |
| Wheelbase, driving | 7 " 6 " |
| Wheelbase, total | 30 " 2 " |
| Length over all | 38 " 9½ " |
| Weight on driving wheels | 68,096 lbs. |
| (Front, 33,908 lbs.; rear, 34,188 lbs.) | |
| Weight on leading truck | 30,576 " |
| " on trailing truck | 35,308 " |
| " total, in working order | 133,980 " |
| Cylinders | 17 x 24 ins. |
| Valve gear | Link motion. |
| Boiler pressure | 160 lbs. per sq. in. |
| Boiler plates | Steel. |
| Tubes | Iron. |
| Firebox | Copper. |
| Heating surface, tubes | 928 sq. ft. |
| " " firebox | 93 " " |
| " " total | 1,021 " " |
| Capacity of bunker | 132 cu. ft. |
| Capacity of tanks | 2,280 U. S. gallons |
| Brakes | Vacuum. |

THE ATLANTIC & PACIFIC RAILWAY TUNNEL CO., which was organized some years ago by the late "Brick" Pomeroy, is now in difficulties and it does not seem likely that its purposes will ever be carried out. The project was to construct a tunnel five miles long through a ridge of the Rocky Mountains in Colorado, for the combined purpose of tapping alleged great deposits of gold and other ores, and of opening a short line of railway communication which would cut down the distance between Denver and Salt Lake City from 770 to 520 miles. The company was organized in 1880 and work went slowly on for some years, but at present only about 1½ miles of tunnel are completed, and this tunnel is, it is understood, only a heading and not of full-sized section for railway purposes. The project was most extensively advertised and a large aggregate amount was subscribed, mainly by small investors. No work has been done for some two or three years, and it is now claimed that owing to non-payment of taxes by the officers of the company the property is liable to be sold to recover the amount of the taxes.

THE INTERLOCKING OF STREET RAILWAY CROSSINGS of steam railways at grade is to be carried out by the Brooklyn Heights Electric Ry. at its grade crossings of the Long Island R. R. The signals will stand normally at "stop" for the electric cars, and will not be lowered by the towerman until he is advised that the block is clear.

THE GROWTH OF STREET RAILWAY TRAFFIC IN New York, in the last 30 years, is thus set forth in the presidential address of Mr. Rogers before the late convention of the New York Street Railway Association at Binghamton:

| Date. | No. of lines. | Elevated traffic. | Total traffic. |
|---|---|---|---|
| 1865 | 11 | ..... | 79,618,818 |
| 1875 | 13 | 644,025 | 140,582,793 |
| 1878 | 15 | 9,236,670 | 169,105,730 |
| 1883 | 15 | 92,124,943 | 266,164,236 |
| 1893 | 16 | 219,621,017 | 453,652,964 |

The Railway Commission's report of 1895 says that the operating expenses, interest, taxes and rentals of all street railways in the State aggregated 91½% of their gross receipts. At this rate, says President Rogers, the dividend on one 5-ct. fare amounts to 4¼ mills. In New York a passenger can ride 12½ miles for 5 cts.; in Brooklyn, 18 miles; and in Buffalo, 13⅜ miles for the same fare. Reduced to mile rates, the transportation charge would be 4, 2.8 and 3.7 mills per mile, which is claimed to be the cheapest transportation rate in the world.

THE CHICAGO & SOUTH SIDE ELEVATED RY., better known as the Alley Elevated, was sold at public auction at Chicago, Ill., Sept. 16, under a decree of foreclosure. The property is capitalized at $18,000,000, but was sold for $4,100,100 to Mr. Leslie Carter representing the first mortgage bondholders' committee and Mr. G. E. Adams, representing the extension bondholders' committee. The company was incorporated in 1888, but the line was only completed in 1893, in time to start with a very heavy traffic of passengers between the city and the Columbian Exposition. Since that time the traffic has been but light and the company has had continuous financial trouble.

A DUST-PROOF CAR has been devised by Mr. E. H. R. Green, General Manager of the Texas Midland R. R., and a car fitted with the necessary appliances has been put in service. According to published descriptions these are water-drenched ventilators located in the walls of the car between the windows, and water-pipes produce a shower of artificial rain in each ventilator. The water is carried under pressure through the pipes to drench each of the wire-fabric air filters in the ventilators. The power is derived from the axle, and is transmitted through the medium of flexible coiled wire bands. The same water is forced through the pipes and ventilators repeatedly, being used over and over again all day. The pumping apparatus is located out of sight under the floor. When the passenger wants a breeze, he turns a knob which throws open the air-deflector on the outside. This catches the breeze produced by the forward motion of the car, and throws it through the water-drenched air-filter into the car. This breeze may be increased, diminished or shut off entirely at the pleasure of the passenger.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision between a light engine and an engine with the pay car on the Cincinnati, Hamilton & Dayton R. R., near Connersville, O., Sept. 18. The light engine was running backward and the other engine, with its car, was thrown from the track. The engineman and conductor of the pay train and both firemen were killed, and three or four persons were badly hurt.——The Brantford express train of the Toronto, Hamilton & Buffalo Ry. was derailed at a switch at Hamilton, Ont., Sept. 17, and the engine was overturned, killing the engineman and fireman.——A broken axle on a box car caused a bad freight train wreck on the Conestoga bridge, of the Pennsylvania R. R., near Lancaster, Pa., Sept. 18. About 20 cars were derailed and smashed, but the bridge was not damaged.

A PREMATURE EXPLOSION OF DYNAMITE occurred Sept. 19, on the tunnel work at Shaft No. 2, of the new aqueduct for the metropolitan water supply system of Boston, Mass., the shaft being situated at Clinton, Mass. Four men were killed. The shaft is 100 ft. deep and the tunnel extends 150 ft. in both directions from the bottom, the explosion occurring in the west tunnel. According to press reports and interviews with the survivors, the day shift at 5 p. m. had drilled 22 holes, 6 ft. deep, and in each hole was placed 6 lbs. of dynamite. The foreman adjusted the wires and the gang went to the surface. Two sections of the blast, about 14 holes, were successfully fired. The men went into the shaft to adjust the wires for the third or clearing blast (to clear the face of the work), and had hardly reached the bottom before the explosion occurred.

A POWDER EXPLOSION, caused by lightning, occurred Sept. 19, at the works of the Hazardville Powder Co., Hazardville, Conn., but nobody was hurt, the explosion occurring just before the time for the men to go to work.

A SUBMARINE WRECKING VESSEL is being built at the Malster shipyard in Baltimore. The inventor is Simon Lake, of Baltimore, and the boat is intended to be used in recovering goods from wrecked steamers, at any depth not exceeding 150 ft. below the water surface. The trial vessel now being built will be cigar shaped, built of steel and will be 40 ft. long and 10 to 15 ft. in diameter. Steam will be used for propulsion on the surface and storage batteries for underwater work. The estimated submerged speed is 8 miles per hour, and the boat will be fitted with bottom man-holes, derricks, powerful electric lights, etc. The wreckage would be loaded into sunken trailing boats, which will be made to rise to the surface by forcing out the water by compressed air. At least, this is the plan proposed by Mr. Lake.

## AMERICAN LOCOMOTIVES FOR FOREIGN RAILWAYS.

The accompanying illustrations represent four locomotives recently built for foreign railways by the Baldwin Locomotive Works, of Philadelphia, Pa., and we are indebted to the builders for the photographs from which our cuts have been prepared.

Fig. 1 is a double-end engine built for the Spanish Military Engineers at Havana, Cuba, for the Jucaro & Moron military railway. It has six driving wheels and a four-wheel trailing truck under the tank and bunker. It will be noted that there is a feed pump worked from the crosshead in addition to the injector. The cab is armor-clad with ⅜-in. steel plates on the sides and front, and lined with ash. The doors and windows have shutters of ⅜-in. steel to slide over the glass panes when required, the shutters being provided with loop-holes in the center to allow of rifle fire to resist attacks.

Fig. 2 is an engine for the Cazadero & Tepetong Ry., Mexico (narrow gage), having six driving wheels and a leading and trailing pony truck, the wheels being mounted inside the frames. It has a large cab, side tanks and a rear bunker.

Fig. 3 is an engine of very similar type to No. 2, but having the wheels outside the frames. It was built for the Krotovka & Sergievsk Ry., of Russia.

Fig. 4 is a mogul four-cylinder compound engine for the Norwegian State Railways, and is peculiar for the wide spread between the main and rear driving wheels. The tender has trucks of the passenger car type. This engine was No. 15,000 built by the Baldwin Locomotive Works.

The leading dimensions of these engines are given in the table below.

## THE NEW ST. LAWRENCE BRIDGE AT MONTREAL.

In 1859, or nearly 40 years ago, the Grand Trunk Ry. Co. completed the celebrated Victoria Bridge across the St. Lawrence River, opposite the western extremity of the city of Montreal. This structure is a single track tubular bridge, and for some years past its capacity has been strained to accommodate the business of its proprietors. The other railways terminating opposite Montreal have had to pay tribute for years to the Grand Trunk Ry. Co.; and it is stated that $5 per car has been a minimum rate for taking freight across the bridge. The Canadian Pacific Ry. has a bridge of its own at Lachine, which is some miles above the Victoria Bridge, and was completed in 1887. The Montreal Bridge Co. now proposes to build a third bridge, at the east end of the city, about 2½ or 3 miles below the Victoria Bridge, this new structure to be for railway, street railway and highway traffic. The general location was shown in our issue of Feb. 11, 1895, about which time the company advertised for competitive designs for its structure, and after some considerable delay the award has now been made, as noted in our issue of Aug. 27, 1896, the first prize going to Mr. E. S. Shaw, C. E., of Boston, Mass. Mr. C. N. Armstrong is the managing director, and Mr. Walter Shanley is the consulting engineer for the company, the offices being at Montreal.

Apart from the Grand Trunk Ry. and other lines controlled by it, there are now two other railways terminating opposite Montreal, as follows: The Montreal & Province line and the South Shore Ry., and under construction, the Atlantic & Lake Superior Ry. Besides these, the Central Vermont Ry. system and the United Counties Ry. reach St. Johns, about 20 miles from the St. Lawrence; the Drummond County Ry. reaches St. Hyacinthe, about 30 miles; the Delaware & Hudson, about 35 miles; and the Adirondack Caughnawaga line, about 10 miles from the St. Lawrence River, opposite Montreal. Several of these lines will, it is stated, be extended to connect with the new bridge and take advantage of the facilities to be provided by it. On the Montreal side of the river, besides the Atlantic & Lake Superior line, there are several shorter lines, including the Montreal Park & Island Ry., the Chateauguay & Northern Ry. and the Montreal Belt Line Ry.

In addition to the traffic to be obtained from these various railway lines, the bridge will obtain a large amount of traffic from local electric lines, special tracks being provided for their accommodation. In mid river is situated St. Helen's Island, with which the bridge is to be connected. This was formerly a fortified station of the British government, and is still the property of the crown,

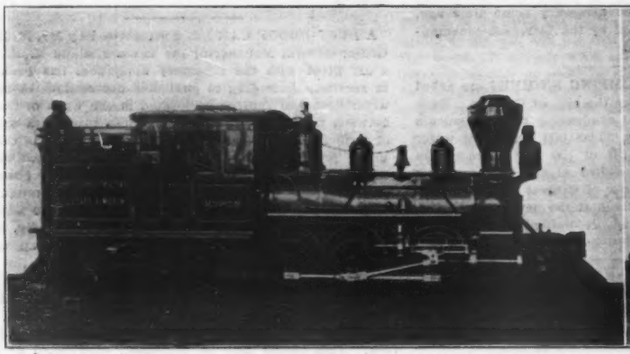


FIG 1.—CUBAN MILITARY RAILWAY.

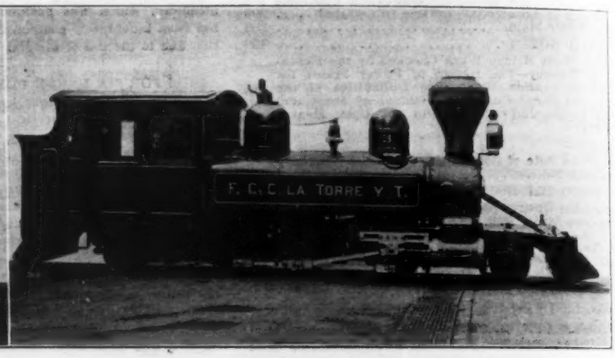



FIG. 2.—CAZADERO AND TEPETONG RAILWAY (MEXICO.)

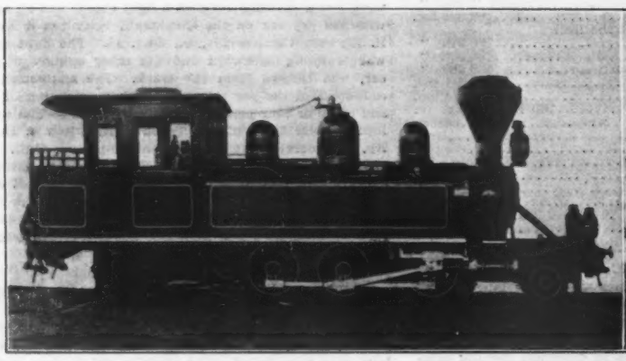


FIG. 3—KROTOVKA AND SERGIEVSK RAILWAY (RUSSIA).

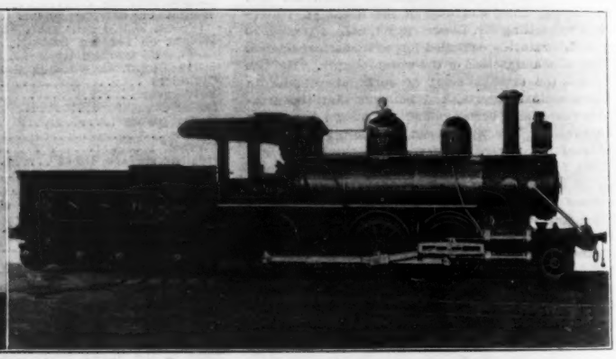


FIG. 4.—NORWEGIAN STATE RAILWAYS.

AMERICAN LOCOMOTIVES FOR FOREIGN RAILWAYS
Baldwin Locomotive Works, Builders.

Dimensions of American Locomotives for Foreign Railways.

| | Fig. 1. Cuba. | Fig. 2. Mexico. | Fig. 3. Russia. | Fig. 4. Norway. |
|---|---|---|---|---|
| Gage | 4 ft. 8½ ins. | 2 ft. 0 ins. | 5 ft. 3⅜ ins. | 5 ft. 6 ins. |
| Driving wheels | 3 " 2 " | 2 " 9 " | 3 " 0⅛ " | 3 " 10½ " |
| Truck wheels | 2 " 0 " | 1 " 10 " | 2 " 0⅛ " | 2 " 2 " |
| Tender wheels | ..... | ..... | ..... | 2 " 2 " |
| Driving axle journals | 5 × 7½ ins. | 5 × 6 ins. | 4½ × 6 ins. | 5½ × 7 ins. |
| Truck axle journals | 3⅜ × 7 " | 3½ × 6 " | 3½ × 6 " | 4 × 6 " |
| Tender axle journals | ..... | ..... | ..... | 3½ × 6 " |
| Wheelbase, driving | 8 ft. 1 in. | 7 ft. 6 ins. | 7 ft. 6 ins. | 12 ft. 0 ins. |
| " total | 19 " 5 " | 19 " 10 " | 19 " 9 " | 18 " 7 " |
| Weight, on driving wheels | 45,560 lbs. | 31,910 lbs. | 33,010 lbs. | 42,244 lbs. |
| " total | 71,960 " | 43,410 " | 47,160 " | 51,844 " |
| Cylinders, high-pressure | 12 × 18 ins. | 11 × 16 ins. | 10 × 16 ins. | 9 × 18 ins. |
| " low-pressure | ..... | ..... | ..... | 15 × 18 ins. |
| Boiler, diameter | 3 ft. 0 ins. | 2 ft. 10 ins. | 2 ft. 10 ins. | 3 ft. 8 ins. |
| Firebox, length | 3 " 2 15-16 | 3 " 1 3-16 | 3 " 10½ " | 4 " 4 7-16 |
| " width | 2 " 9⅝ ins. | 2 " 6⅝ ins. | 1 " 9½ " | 2 " 6¾ ins. |
| " depth | 3 " 10½ " | 3 " 4½ " | 3 " 7 " | 4 " 1½ " |
| Tubes, number | 94 | 62 | 70 | 157 |
| " diameter | 1¾ ins. | 2 ins. | 1⅞ ins. | 1½ ins. |
| " length | 11 ft. 0 ins. | 10 ft. 11 ins. | 10 ft. 1 in. | 8 ft. 1 in. |
| Tank | Rear. | On sides. | On sides. | On tender. |
| " capacity, gallons | 1,000 | 550 | 600 | 1,400 |

but the city has been allowed the use of the greater portion of it as a park, and it has now become what may be called the Coney Island of Montreal. Access to it is now had by means of ferry steamers, but as the street car lines do not reach the docks whence the steamers ply, the traffic is not as great as it might be with better facilities, though the daily attendance is large and on special days reaches to between 10,000 and 20,000. The construction of the bridge would allow the electric cars to take passengers from all parts of the city and land them on the island, and it is expected that the number of visitors would in this way be enormously increased.

The most urgent need of the bridge, however, is said to be for vehicular traffic, which is now completely suspended for nearly three months each year. During the summer season ferry steamers ply to several points on the opposite shore, but the advent of winter drives these steamers into shelter, and until the river becomes a solid mass from shore to shore there is no means of taking a vehicle across. This state of things lasts from four to eight weeks, according to circumstances. When the ice roads are opened all goes well until the hot sun of March makes itself felt, and the ice gradually softens and the roads become dangerous and are closed to traffic. Several weeks elapse before the break-up and disappearance of the ice and the opening of navigation, when the ferry boats make their appearance again. As the city of Montreal obtains a very large proportion of its food supplies from the opposite side of the river, this blockade at regular intervals raises the price of commodities, particularly to the poorer classes, who cannot lay by a store for the time of scarcity. The rapid current of the river, six miles an hour, at the place where the bridge is located prevents the placing of a pier in the channel, thus necessitating a span of at least 1,250 ft. in the clear; and as this span crosses the main ship channel, a headway of 150 ft. has to be provided.

The distance from the south shore to the city station of the Grand Trunk Ry., by its own line, is 6½ miles, while by the new bridge to the new central station, which is to be more conveniently situated than that of the Grand Trunk Ry., it will be only 3 miles. The new bridge being double track, and the line in the city being elevated, there will be no delays, while the Grand Trunk Ry. comes into the city on the level, crossing about 20 streets, where gates and watchmen are maintained. The bridge trains will be worked entirely by electricity, and in the city its tracks will be carried through the blocks on land purchased by the company, and it will in no way interfere with the streets. The company is not prepared to make public at present the location of its line or its terminus in the city.

The heavy expenditure necessary for the construction of the bridge has hitherto prevented its being built, but it is said that the Canadian government, the provincial government of Quebec and the city council of Montreal will assist in the construction of the bridge, which the company proposes to complete so as to open it during the great International Exposition to be held in Montreal in 1898.

## THE BERTRAND-THIEL OPEN-HEARTH PROCESS.*

By Joseph Hartshorne, M. Am. Inst. M. E.**

For something over two years past a new development of the open-hearth process has been in operation at the works of the Prager Eisenindustrie-Gesellschaft at Kladno, in Bohemia. It was devised and perfected by Mr. Ernst Bertrand, general superintendent, and Mr. Otto Thiel, steel works superintendent. The results which the inventors wished to obtain were to increase the product per furnace, to reduce the amount of refractories and additions used, to enable a poorer and more varied quality of stock to be employed, to improve the quality of the material produced and to render the control of the operations and product more certain. In all of these objects they have been successful, and have thereby considerably reduced the cost of manufacture and increased the value of the finished material.

The plant consists of one 12-ton and one 20-ton furnace. Through an incident of construction the smaller furnace stands some distance behind and to one side of the larger furnace, and at a height of about 10 ft. above it.

The relative position of the furnaces suggested the experiments by which the process was developed, and also enabled it to be thoroughly tested. The plant is not as convenient and suitable as one especially designed for the process would be, nevertheless the pecuniary and technical results have warranted its continuous operation.

The process consists essentially in dividing the charge between the two furnaces, tapping the metal from the upper into the lower one and removing the slag from this metal during its progress from one furnace to the other.

Both furnaces are at work on the basic system, although this is not an essential feature of the process. Pig-iron high in phosphorus and silicon is charged into the upper furnace with a small portion of the scrap, if desired, and also a certain quantity of ore and limestone. The remainder of the scrap is charged into the lower furnace, together with pig-iron and a small quantity of limestone. A little ore is also added, if necessary.

The upper furnace is first charged and the metal is melted and made hot. This takes about three hours. By the end of this time the metal is hot and fluid, the silicon is all in the slag and the carbon and phosphorus are to a considerable degree eliminated. It is then ready for tapping.

The lower furnace is charged about two hours later than the upper one. By the time the heat in the upper furnace is ready for tapping the metal in the lower one is also fluid.

The primary furnace is then tapped, the slag being carefully skimmed off the metal as it passes down the trough and prevented from entering the secondary furnace. As soon as the two metals mix together a very lively reaction ensues, which quiets down in about quarter of an hour. The phosphorus is then below 0.03% in the bath. The heat is finished by addition of ferro-manganese or spiegel, and is ready to be tapped, if no further improvement in quality be desired. Fifteen minutes longer in the furnace brings the phosphorus below 0.02%.

It is evident that the character of the charges in the two furnaces will vary materially with the local conditions affecting the supply of raw materials. Where scrap is cheap and plentiful, more will be charged into the primary furnace and the charge in the secondary one may contain no pig-iron at all. Where scrap is scarce and dear, none will be charged into the primary furnace, and only the commercially available amount will be used in the secondary furnace. In all cases the material higher in silicon, phosphorus and sulphur will be charged into the primary furnace and the available amount of purer material will be charged into the secondary furnace together with the necessary amount of other stock.

According to the practice now followed the charges are as follows:

| | Upper Furnace. Tons. | Lower Furnace. Tons. |
|---|---|---|
| Basic Bessemer pig-iron | 7.5 | 1 |
| Steel scrap | 5.5 | 8 |
| Limestone | 0.15 | 0.8 |
| Magnetic iron-ore | 0.20 | none |

The lower furnace is charged about two hours after the upper one. The metal in the upper furnace contains 0.6 to 0.9% of phosphorus when tapped into the lower one, while the metal contained in the lower furnace is already highly oxidized and very low in phosphorus. After uniting the two metals it takes 15 to 20 minutes to reduce the phosphorus to 0.020%.

At present from 5 to 6 heats, of 22 tons of metal charged, are made at Kladno in 24 hours. The lower furnace is empty more than half of the time. It is evident, therefore, that with two primary furnaces at least 10 heats could be made in the 24 hours. The present capacity is from 110 to 132 tons (charged weight) in 24 hours; and this will be doubled by the use of another 12-ton primary furnace, which is now being erected and will soon be at work.

In order to show in more concrete form the advantages derived from the new process, the following extracts, taken from the Kladno reports and cost sheets for the five months immediately before and after its adoption, are here given:

(The paper gives a set of tables with detailed figures. We summarize the principal results as follows.—Ed.)

Comparative results of the ordinary Open-Hearth and the Bertrand-Thiel Process.

Consumption in lbs.—per 2,240 lbs. of ingots.

| | Process, old, average, lbs. | Process, new, average, lbs. | Decrease, lbs. | Decrease, P. c. |
|---|---|---|---|---|
| Melting-coal | 785.3 | 748.97 | 336.33 | 4.63 |
| Heating-coal | 126.2 | 55.64 | 70.56 | 55.80 |
| Steam-coal | 264.3 | 212.93 | 51.37 | 19.40 |
| Limestone | 344.1 | 162.85 | 181.25 | 52.68 |
| Magnesite | 53.7 | 25.09 | 28.61 | 53.20 |
| Cost, basic refractories. | $0.597 | $0.256 | $0.341 | $57.10 |
| " acid " | 0.708 | 0.375 | 0.333 | 47.00 |
| | Tons. | Tons. | Increase | |
| Output, ingots, per heat | 15.39 | 18.64 | 3.25 | 21.10 |
| " " pr 24 hrs. | 37.64 | 64.89 | 27.25 | 72.30 |
| Allowing 20 tons inc.*. | ..... | 64.89 | 7.25 | 20.20 |

*For the small furnace.

These figures give a clear idea as to what was accomplished during the first five months in which the process was at work.

The total cost of conversion was reduced 27.50%. The output increased 72.3%; but, of course, some of this was due directly to the use of a second furnace. A fair allowance for the product of this furnace would be 20 tons per 24 hours. If this be allowed for, the increase in product was 20.20%. The increase under present practice is much greater, being about 50%.

A plant of two 10-ton furnaces and one 20-ton furnace would have a capacity of at least 10 heats in 24 hours, as shown above. This would give from 200 to 240 tons of ingots. A very good product from these furnaces, run separately, would be 5 heats in 48 hours from each, or 2½ per day. This would give 25 tons from each of the small furnaces and 50 tons from the large one, or a total of 100 tons of ingots. It seems reasonable to suppose, therefore, that the capacity of such a plant would be more than doubled, if run under the Bertrand-Thiel process.

Besides these advantages, which are shown by actual figures, it is claimed that the amounts of deoxidizers and recarburizers used are also reduced, and that the loss is smaller. The work of the ten months contained in the table does not show any material difference between the two processes, so far as average loss is concerned; the difference in favor of the Bertrand-Thiel process being only about 0.10%. It is reasonable to suppose, however, that with more experience this feature may be improved. The secondary furnace contains only a small amount of slag, which is comparatively free from oxide of iron at the end of the operation. There should be, therefore, less loss of metal as oxide; and a smaller amount of oxide in the bath, both of metal and slag, should require a smaller amount of deoxidizer to free the steel from red-shortness. This point, however, is somewhat difficult to determine, since so many specifications require more manganese in the steel than that which is necessary to make it roll well.

The control of the quality of the finished product is very complete. Steel is made to specifications within a range of from 0.06 to 1.25% of carbon. The phosphorus can be run down below 0.02% with ease; the sulphur is kept below 0.03%, and the manganese can be regulated very closely. As an instance, it may be stated that a large amount of steel has been made containing 0.80 to 0.90 carbon. This steel was used for bayonets for the Italian army and the results were very satisfactory.

The work of the past year has shown that from 65 to 75% of the sulphur is removed by this process.

*Abstract of a paper read at the Colorado meeting of the American Institute of Mining Engineers, Sept., 1896.

**119 South Fourth St., Philadelphia, Pa.

## THE TONNAGE RATING OF FREIGHT TRAINS.*

Mr. Brunn (Erie R. R.).—Our experience with the tonnage system began in the month of June this year, although the system has been under consideration a good many years, but we did not, until that time, make up our minds to follow it. The results have been highly gratifying to the local officers and I believe to the general officers of our company. We keep a very careful record of the number of cars in a train load and by so doing we are able to figure the money value received. A great saving has been made in light loads—that is, we haul on our line a great many cars of merchandise in which we do not get the full capacity of the cars; in some instances where our train load under the old system of loading was 30 cars we have been able to pull as high as 40 cars. Again in some instances where we were hauling heavy dead freight we had to reduce the number of cars in trains, but no doubt this was a great benefit in preventing the stalling of trains on grades, and securing greater regularity in train movements. We first started to load on the ton basis; but we now load trains by the thousand pounds or by the "M." This simplifies the work of getting the load. Instead of taking the number of cars and saying so many tons, one simply takes off the first two figures of the weight of the car. For instance, a car weighs 20,700 lbs. The car is counted as 21 Ms.

In loading a car at the warehouse, the bill of lading or shipping receipt always shows the weight of each shipment, and the shipping clerk makes a note of them, and if it is a mixed car, with different consignments in the same car, he deposits the bill in an envelope and puts the gross weight of the car and contents on the outside of the envelope. If the car is forwarded under that envelope, with the original bills, the yardmaster gets the weight from that envelope. If the bills are sent forward in advance of the car by passenger train, there is a car way bill made out, on which is shown the car and contents.

The first thing done is to take the total weights on the shipping orders before any manifesting is done, and supply the yardmaster with the information. It is a very simple matter for the clerk to take the contents of the car and put it on. The yardmaster gets the total weight and notes it on the card about as quickly as he gets the car itself, and we have loaded out from 75 to 90 cars of mixed mer-

*Abstract of the discussion on the report of the Committee on Transportation, of the American Society of Railroad Superintendents, presented at the recent meeting at Niagara Falls. The report was given in the report of the proceedings in our issue of Sept. 17.

chandise a day, and have experienced no difficulty in the matter.

On a road on which coal or ore originated along the line, at points close to the terminus of a division, we might not get the weight until we were ready to move, but my understanding is that coal is always weighed at the tables where it is loaded, and in that case we would take the shipper's weight. We do not hesitate in taking the weights of the shippers, as we have found in most instances that their weights are nearer correct than our own. A track scale is not always to be relied upon for weighing coal as it goes over the table.

Mr. C. B. Price (Allegheny Valley R. R.).—On many roads I know the custom is to weigh at a railway track scale generally placed at a point where the product of a great many mines pass over it. The manifesting is made from this weight. The scale on which the most of our weighing has been done is pretty well up the line for the purpose of catching everything originating at that point. We never take the shippers' weights; they take ours, and are only too glad to get them. If they weigh their coal at the mines it is to test the weights received from us.

Mr. Trump (Pennsylvania R. R.).—It is the practice of my division to weigh the coke, for instance, which comes from the southwest branch, at some common point and to do the manifesting on those weights. The coal shippers all have their own scales, but they use our weights for invoice purposes altogether. In the makeup of trains we would be governed by the returns from the official railway scales.

Mr. Roberts.—I think you can arrive at the information you desire by approximating the capacity of the cars; that would not affect the tonnage of the train, as you get the weight sufficiently near to make up your train. Our cars are loaded at a point where there is an accumulated product of the mines; the actual weight is taken there and sent back to the shippers, and they accept our weights. So far as obtaining information for the maximum capacity of our engines is concerned, we take the estimated weight of the load and cars. With the exception of the coal trains we are not loading trains on the tonnage basis. As to trains of empty cars our first method was to add 25% to the weight of cars for an empty train, and it was not enough; it made a bad showing. At a certain point where the tonnage rating showed we could haul 77 empty cars we could actually haul only about 48, then we changed the method and added 60% to empty trains, and that is not enough, and we have about made up our minds that we should add 70 or 75%.

Mr. Knibloe (Buffalo Creek R. R.).—In order to have a perfect application of the tonnage methods we must have the facilities requisite for such application. It was the opinion of the committee, as expressed in its preliminary report a year ago, that the percentage of economies in either direction, in the time the train moved and in the additional number of cars hauled and the decrease in the trains run, was so great that railway companies could afford to go to considerable expense in putting in track scales and the employment of extra clerks in order to secure a substantial conformity to the tonnage standard, whatever it might be for the different classes of engines. As to empty trains it seems to me the number of empty cars should be that which one crew can cover with safety; the crew should be able to pass safely from the rear to the engine and not have the desire to load up to the full capacity of the engine, taking the actual stencil weight of the cars.

Mr. Potter.—The result of that would be to make a very bad showing on the hauling capacity of the engine in a certain direction, and the question is brought to your attention, "Why do you not load your engines to their full capacity?"

Mr. Knibloe.—I never had experience where the movement of loads in one direction was so very much in excess of the other direction as Mr. Potter suggests.

Mr. Price.—The question that arose is one we met the other day on the Allegheny Valley R. R., and therefore I can undertake to give an answer. If the preponderance of tonnage is in one direction, it follows there must be a large percentage of light power movement in the other. If you take one engine, returning in the direction of the light movement, and load it down with the full capacity of empties, the next might go through without any load—it might be what is called "a horse and buggy train." If you limit the load of empties under the conditions specified by Mr. Knibloe, with reference to the length of the train, facilities for signaling, etc., you will strike a fair average of partially light movement.

Mr. Potter.—I agree that there is a limit to what a certain train crew could handle. We do not attempt to handle more than 50 empties. That suggestion is all right providing you can control your empties, but if they are forced on you so that you must run light power after your empties during a certain period, you want that power coming back hauling as many empties as they can.

Mr. Price.—It never happens that we have to send power up after empties. The next train moving in that direction would have perhaps more than the average number of empties.

Mr. Fitch.—The question is a good deal of an experiment. After several months we came to the conclusion that the best way was to build a dynamometer car which told us exactly what the engine could do. It does not cost very much. We are building such a car. A few days' experimenting will tell you exactly what your engine can pull under any conditions.

## 60,000-LB. BOX CARS FOR THE BALTIMORE & OHIO R. R.

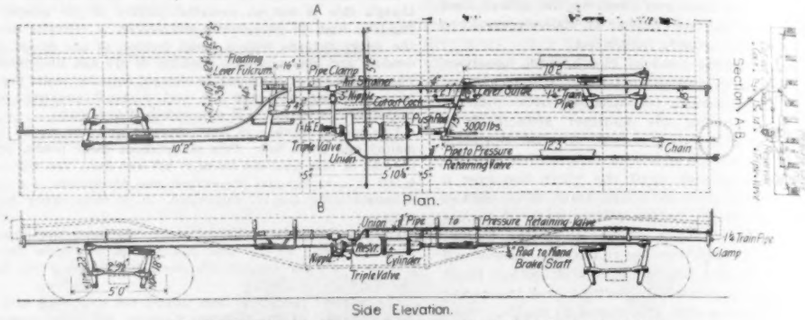
(With inset.)

A few months ago the Baltimore & Ohio R. R. placed orders for 4,600 new freight cars, and these were described somewhat fully in our issue of June 11, 1896, when an abstract of the specifications was given. Of the total number of cars, 2,300 were box cars, and the drawings of these cars are given this week on our inset sheet.

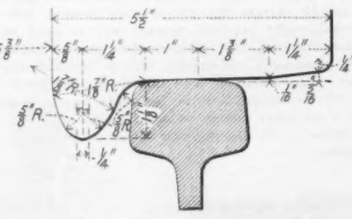
There are two side sills 5×8 ins., four intermediate sills 3×8 ins., and two center sills 3½×9 ins., all of yellow pine and tenoned into oak end sills 8×10 ins. The frame is trussed by four body truss rods 1¼ ins. diameter, with threaded ends upset to 1⅜ ins., there being a pair of rods each side 17 ins. c. to c., while the inner rods are 4 ft. 2 ins. apart. The truss depth is 22 ins. and the distance between truss-rod bearings is 6 ft. 3¼ ins. These bearings are bolted to tie-timbers 5×10 ins., set on edge below the sills. To the end sills are bolted oak buffer blocks 5×11¾ ins., 3 ft. 1 in. long, with malleable iron buffer heads. The draft timbers are 4×9½ ins., placed under the center sills and extending back to the body bolsters, the Buckeye M. C. B. couplers being connected up by the American continuous drawbar. The body bolsters are built up of three white oak sticks, 4½×6½ ins., and two wrought-iron plates, ¾×6 ins., and each bolster is trussed by two 1-in. rods, with 1⅛-in. upset ends, passing through the bolster and the intermediate sills.

The side framing consists of posts and body braces 3×5 ins., with ¾-in. vertical rods; the end posts are 4×5 ins., and corner posts 5×5 ins. The outside sheathing is of ⅞-in. tongued and grooved planks 3 to 4 ins. wide, placed vertically, and inside these is a lining of ⅞-in. tongued and grooved plank laid horizontally; this lining extending from 2½ ins. above the floor up to the side girth, and is 5×4 ins. The end plate is a 4-in. plank, 14 ins. deep at the middle. The loading limit is marked by black lines, 4 ft. 6½ ins. from the floor for corn and 4 ft 3 ins. for wheat. The roof is of the Chicago pattern, composed of metal and wood, the metal sheets being covered by the outer planking. The floor is of 1¾-in. planks, 5 to 8 ins. wide, laid transversely across the sills and secured by 20-penny nails. The outside of the car is painted with three coats of brown mineral paint, with the lettering in white, and all ironwork is given one coat of asphaltum or smokestack black.

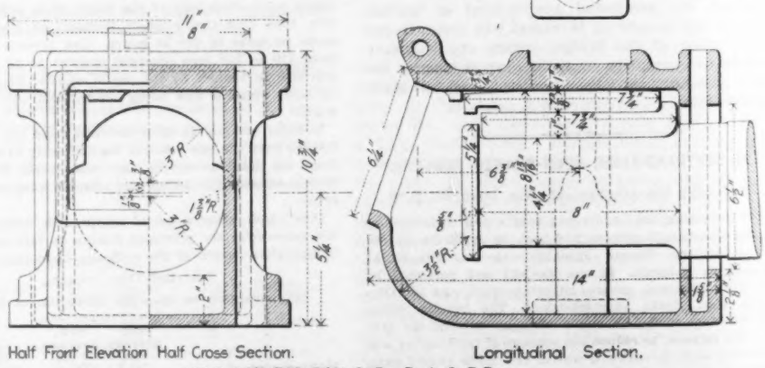
The trucks are of the diamond frame pattern, with top arch bars 1¼×4 ins., lower arch bars 1×4 ins., and tie-bars ⅝×4 ins. The bolster is built up of two white oak sticks 3½×11½ ins. and one stick 6×11½ ins., flitched by two wrought-iron plates ⅞×8 ins, 7 ft. 5 ins. long. This is trussed by two 1⅛-in. rods with 1¼-in. upset ends. Under each end of the bolster is a nest of four spiral springs, resting on the spring plank, this latter being an inverted 12-in. channel iron. Some of the cars have the American cast-steel bolster and others have the Schoen pressed steel bolster. The journals have lead lined brasses and are protected




ARRANGEMENT OF BRAKE RIGGING ON BOX CAR; B. & O. R.R.



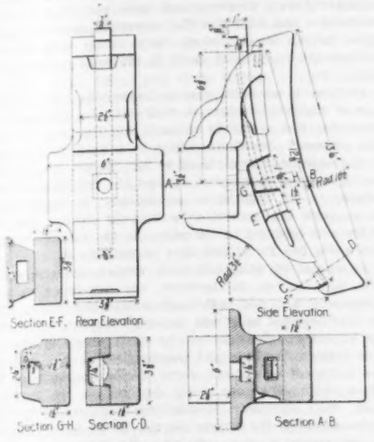
Wheel Tread and Rail Head; B. & O. R.R.




AXLE BOX FOR BOX CAR; B. & O. R.R.

by Stier's dust guards of yellow poplar or basswood. The cast-iron wheels are pressed on the axles with a pressure of about 60,000 lbs.

The cars are fitted with the Westinghouse brake, and the general layout of the brake apparatus is shown on one of the drawings. The instructions for setting up the air brake apparatus provide that the relative angle of levers must be maintained when attaching the brake rigging to the cars. The pipes are to be blown out with steam after bending, and all connections must be perfectly tight when tested under pressure with soapsuds. Red lead must be used sparingly at joints, and put on the outside of the pipe that screws into the fitting, never on the inside of the




**Brake Shoe for Freight Car; B. & O. R.R.**

fitting, as it is liable to get into the triple-valve and interfere with the working of the brake.

The cars were designed by Mr. Harvey Middleton, General Superintendent of Motive Power, and Mr. E. W. Grieves, Superintendent of the Car Department.

The general dimensions of the cars are as follows:

| | | |
|---|---|---|
| Length: | | |
| Over end sills | 36 ft. 10 | ins. |
| Over body sheathing | 36 " 11¾ | " |
| " running board | 38 " 5 | " |
| " couplers | 40 " 1¼ | " |
| Inside | 36 " .. | " |
| Width: | | |
| Over side sills | 8 " 10 | " |
| Over body sheathing | 8 " 11¾ | " |
| " eaves | 9 " 7 | " |
| Inside (between girths) | 8 " 2 | " |
| Extreme (over bottom slides of doors) | 9 " 8¼ | " |
| Height: | | |
| Rail to c. line of coupler | 2 " 10½ | " |
| Rail to eaves | 12 " 6⅜ | " |
| " to running board | 13 " 4⅝ | " |
| " to top of brake shaft | 14 " 0½ | " |
| Side sill to side plate | 7 " 5½ | " |
| Floor to carline | 7 " 7¼ | " |
| Doorway | 7 ft. 3½ ins. × 5 ft. 6 | " |
| Axles: | | |
| Length, c. to c. of journals | 6 ft. 3 | " |
| Diameter at middle | 4⅝ | " |
| " at wheel seat | 5¾ | " |
| Journals | 4¼ × 8 | " |
| Wheels, diameter | 2 ft. 9 | " |
| Wheelbase, truck | 5 " .. | " |
| " total | 31 " 10 | " |
| Distance c. to c. of trucks | 26 " 10 | " |
| Carrying capacity | 60,000 | lbs. |
| Cubic capacity | 2,254.5 | cu. ft. |
| Weight, empty | 32,362 | lbs. |
| Cost (approximate) | $510 | |

## BLOCK SIGNALING AND INTERLOCKING.*

Mr. Derr (Erie R. R.).—My division is divided into 43 block sections, ranging from a few hundred feet to 3½ miles. In the yards we operate the block system, the same as on the line. Our block system is largely manual, with electric bells connected between the towers; the signaling being done by the ordinary code, so many taps of the bell meaning certain moves and directions. At the outlying stations where there is a cross-over, we have the distant signal located not less than ¼ mile from the home, and running up as far as 3,200 ft. The home signal is located near the cross-over and protecting the cross-over switches, and the advance signal is about a train length ahead of the home signal. At some cross-overs we also have signals for directing the movements from the cross-over to the advance signal. A great many cross-overs are locked with the home signal, so that no movement can be made over a high speed line except when the switch is set for the line movement. Our rule or direction on signaling to our men is that they may run up to the home signal but not beyond it when at danger; that may be laid down as the fundamental principle of signaling. The home signal governs to the advance signal and no further; after bringing the train to a full stop no clear movement can be made; you give permission to go to the advance signal and no further. In other words, the advance signal cuts the block or section into two parts, and the home signal governs only to the advance signal.

Mr. Trump (Pennsylvania R. R.).—We use the telegraph block system on the main line divisions. The signals are given by the semaphore. We do not use the track circuit except in special cases. We use the automatic electro-pneumatic semaphore system, with the exception of a few electrical signals. In regard to the use of the absolute block, we have been able to do away with this feature, especially on divisions like the Western Division, where we handle heavy trains and grades. We have not money enough to put in the block stations every half mile.

Mr. Brunn (Erie R. R.): On our Buffalo Division when we first started the block signal system we found the expense of adopting an absolute block would be very great, and after considerable arguing with our people, I succeeded in getting them to permit me to put in the block, and made the block positive in reference to passenger trains—that is, a passenger train following a passenger train would block before and behind; a freight train following a passenger train was blocked before and positive block behind, etc., insuring positive safety to the passenger trains. Where a freight followed we allowed the trains to go on the block with caution signal, separating them 15 minutes apart. The blocks in many cases are seven or eight miles long. We operated that system several years with very satisfactory results. Where it was possible we let one train follow another under green signal. We finally decided to introduce the absolute block in reference to freight trains. We often found it was necessary to close up freight trains at important points, where we had ample siding facilities, and let the passenger trains (or trains of superior class) go by. In doing that we never let the following train into the block until we knew absolutely where the leading train was, then we gave the conductor or engineman an order or message indicating just where the obstruction is, and let them proceed under the caution signal. That is, perhaps, as near the absolute block as you can get; tell the man where the train is and let them go to that point by using their own judgment. Our system permits the use of the green signal under the circumstances I have stated. When we know a train is at a siding and about to pull in, then we send the order to the following train, which is delivered to both conductor and engineman, telling them the train is drawing into such siding, and allow them to go into the block under the green signal. We never give them the white or clear signal. The train order is a message which the telegraph operator is required to give to both conductor and engineman, and they cannot proceed without that message.

Mr. Trump.—I would like to see the absolute block on all railways, but with heavy trains and heavier freight trains it seems to us impossible to adopt the absolute block system. It costs us about 25% more to run under this system. Some roads use the siding, and forward trains under caution card; and also use the clearance card in case anything goes wrong. There are cases where they give the engineman a card to stop a train and deliver the card to the next operator. On the division having the Westinghouse automatic signals, with track circuits, we have to provide for the contingency of the signal constantly sticking at "stop." If a train finds the signal at danger, it comes to a full stop, and then proceeds the same as with a caution card, looking out for broken rails, etc. The time of stop required is two minutes, as it takes about that long for a freight train to get stopped and start again. Occasionally a signal may be out of order, and this sometimes occurs by the carelessness of the track-men in handling ties, dumping cinders or something of that kind. They connect the two sides of the track circuit.

Mr. Price (Allegheny Valley R. R.).—We have had, during the last six months, two short sections in the Pittsburg yard equipped with the overlapping block signal apparatus with disk signals, as described by Mr. Schreuder yesterday (Eng. News, Sept. 17, 1896). The sections are short, about ¼ mile each, protecting the operations of the yard, which is considered especially hazardous. They have worked very well, but it happens sometimes that the signal sticks at the red or "stop." It may be on account of wet weather. Wet affects the conductivity of the track sections and makes the signals slow to release from the stop position after the trains have cleared. To cover this contingency we have adopted the regulation that after a certain interval of time a train stopping at the "stop" signal may proceed. With that little regulation supplementary to the mechanical arrangements we have been able to get along very well with the signals. I wish the whole of our railway yards were protected in the same way. I recall instances where passenger trains were held for short intervals, since we had this system in operation. It is connected to the inside of the switches on cross-overs as well as the main track switches. We have had one or two cases where the yard crews, standing on the siding waiting for passenger trains to pass, would open the inside of switch so as to be ready to go ahead; the effect was to keep the signal at "stop," and produced a little delay to the passenger trains. It was due to the ignorance on the part of the trainmen, and it was only necessary to call their attention to it in order to secure its correct working. I mentioned wet weather as one of the conditions affecting the track circuits. On the Pan Handle road, where they have the track circuits, they have had the same experience.

Mr. Schreuder (Union Switch & Signal Co.).—In regard to track circuits in wet weather, we find that where tracks are laid with cinder ballast close to the rail, we have a lag in the track circuit during wet weather. Of course in working the track circuit, you must limit the length of the circuit in accordance with the condition of the track. Where the circuit passes through many switches and yards, the length should be regulated accordingly, and the battery must be located so as to be at the lowest tension possible. We can under ordinary conditions work a track circuit one mile long with one cell of battery, when the rail is not touching the ballast; when close to the ballast, as in yards generally, we are obliged to have more battery. In some cases we have had considerable trouble with the track circuit where it is parallel with trolley roads, but have overcome it by using a double insulation and grounding, in some cases.

*Abstract of discussion at the meeting of the American Society of Railroad Superintendents, at Niagara Falls, N. Y., Sept. 9, 10, 1896.

## THE POLE GAS-MOTOR STREET CAR.

By T. C. J. Baily, Jr.

A street motor car operated by a gasoline engine has been tried recently on the line of the Anacostia Ry. Co., of Anacostia, D. C., and its mechanism is the invention of Mr. T. C. Pole, of Washington, D. C.

This motor may be described as a 20-HP. horizontal gas engine, with cylinder 9×14 ins., mounted in the center of an open car, 20 ft. long and with a seating capacity for 19 passengers. The motorman on the front platform handles a wheel which, being turned to the right engages the sprocket wheel and chain by means of a friction clutch to two 36-in. driving wheels; while turned to the left, it throws off the clutch and puts on the brakes. The cylinder is just above the floor, with a 100-gallon water cylinder, or tank, above it. To one side and on the level with the water cylinder is the gasoline tank, made of ¾-in. boiler iron, 14 ins. outside diameter and with a capacity of 7 gallons. Two heavy fly wheels, 5 ft. 6 ins. diameter, steady the engine, the engine and fly wheels running constantly at a uniform speed independent of the speed of the car. There are two sets of gearing, for speeds of 6 and 12 miles an hour. The explosion is at present accomplished by a spark from four Leclanche cells, and the engine exhausts into a muffler underneath the car, this exhaust being scarcely audible. The entire outfit, including engine and car, weighs about seven tons and is designed to haul one or two trailers. The following results were obtained on a trial trip made about midnight of August 20.

The motor was geared up to a maximum speed of six miles per hour, the test not being for speed so much as for economy and efficiency. It took about a minute to start the engine, after which it ran steadily, the car itself being started and stopped several times to see how quickly it responded. One hill, 1,300 ft. long, beginning from a curve, was climbed, its grade varying from 2.6 to 5.2%, with 4.14% for 600 ft. The car took the hill easily. On a 4.14% grade it was stopped and started with no perceptible slipping. A start was also made from the middle of the sharpest curve on the road. The hill mentioned was the only one encountered on the run of 9,400 ft. The road is a rough one, about half a mile of it not having been used for several years and being covered with sand. Over this part the speed was about 4 miles, but for some distance 6 miles per hour was actually maintained.

As a consequence of the rough track, only when the engine was running and the car at rest could any opinion of the vibrations and noise be formed. This vibration was considerable and mostly longitudinal; heavier fly wheels might lessen it. The wooden casing was taken off, so the noise was far more than it would be in actual service and was very great. It should be remembered, however, that the parts are new and necessarily work stiffly. The gasoline also smoked badly once after a long stop, due to an overcharge, but while running there was only a slight odor.

The inside diameter of the gasoline tank is 12½

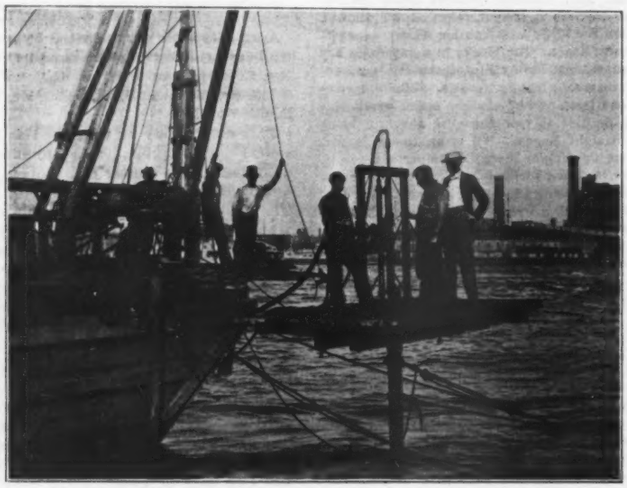
ins. At the end of the run the depth of the gasoline was measured and it was found that 1½ ins. had been used. This means 0.8 gallon for a distance of 1.8 miles. Taking the retail price of gasoline at 8 cts. per gallon (what it cost the parties making the test), would give on this run a cost of 3.6 cts. per mile for fuel. The temperature of the water rose from 80° at the start to 120° at the finish.

Mr. Pole has received permission to run his car over the Belt Line tracks and also those of the Brightwood electric line, which has a smooth track and a couple of long grades.

## DIAMOND DRILL BORINGS FOR THE NEW EAST RIVER BRIDGE PIER FOUNDATIONS.

As a preliminary to founding the towers of the new East River bridge, an exploration of the character of the soil and the depth to the solid rock at each tower site was essential. This was at first attempted by driving pipe to the rock, or to what appeared to be rock, and then exploding a dynamite cartridge on the surface of the supposed rock. If the pipe failed to sink any further the testing party assumed that bed-rock was reached; reaching a boulder that could not be broken up, or driven aside, a hole was drilled through it with the drop-tools, and a smaller pipe was inserted and driven down; and this process was repeated until bed-rock was assured. In several instances a boulder was mistaken for solid rock, until the diamond drill exposed its pretensions. Bed-rock once actually reached a 2-in. pipe was seated in the rock in such a manner as to form a sand-tight joint; the scow was drawn back a few feet from the hole and a platform, 8 by 10 ft., made of 6 by 6-in. timbers and floored with 2 by 6-in. plank, was lowered over the top of the 6-in. pipe and firmly clamped to it by bolts. The pipe, with its platform, was stayed against vibration by means of separate anchors and by purchases attached to the anchor lines of the scow. The diamond drill and its frame was then mounted upon the platform; and for these borings a very light drill, designed for underground mining exploration, was adopted and proved well suited to the work. Steam hose and water hose connected the drill on the platform with the boiler and pump on the scow.

The original pipe-borings were found to be misleading, after the diamond drill had been set to work. Instead of 50 ft. to bed-rock, on the New



MAKING DIAMOND DRILL BORINGS FOR THE FOUNDATIONS OF THE NEW EAST RIVER BRIDGE PIERS.
The New York & New Jersey Well Co. and the American Diamond Rock Drill Co., Contractors.

and on this supposition rock was indicated at 50 ft. below the water surface on the New York side, and at 75 to 80 ft. on the Brooklyn side.

These tests, however, were not satisfactory and conclusive to the engineer of the bridge, and he decided to have borings made with a diamond drill to such depth as would establish beyond doubt the true position and character of the rock foundations. Bids were called for and the contract was let to the New York & New Jersey Well Co. and the American Diamond Rock Drill Co., of New York.

The method of carrying on the diamond drill work is indicated in the accompanying photograph. The strong tideway and the heavy swell from passing steamers made work from a floating platform impossible, and to drive piles for each boring would have added heavily to the expense when the depth of water was considered; this depth was comparatively small on the New York side, but on the Brooklyn side the water ranged from 49 to 60 ft. deep. The use of a trussed and anchored pipe, similar to that employed on the test-borings in the Northumberland Straits, was also rejected, owing to the variation in depth and the desirability of starting some of the holes with small pipe and others with pipe of large diameter.

The plan of the work finally adopted was as follows: A pipe was first jetted and driven to the bed-rock by the use of the boring machines of the New York & New Jersey Well Co. These machines were mounted on the bow and stern of a large scow; and heavy drive-pipe was used, with the holes usually started with a 6-in. pipe, though 8-in. pipe was driven down in some places. On York side, the true depth was found to vary from 46.1 ft. to 68.3 ft.; and on the Brooklyn side, the true depth ranged from 80 ft. to 104 ft. In only one case out of 22 holes bored did the two sets of borings agree; in all other cases the supposed solid rock proved to be merely a boulder. The actual distances bored into the bed-rock by the diamond drill ranged from 10 ft. to 20 ft., these depths being considered sufficient to prove the character of the foundation. In nearly every case a few hours' work, after setting up the drill on the platform, was all that was required to complete the hole, and no difficulty was experienced in working from the platform, notwithstanding an unusually strong tide and heavy swells from passing boats. A core was furnished for each hole, showing conclusively the character of the rock. As the small drill used had a capacity of 350 ft. the holes could easily have been carried deeper, had this been deemed desirable. In all, 22 holes were drilled; 10 on the New York side, at the foot of Delancey St., and 12 on the Brooklyn side, at the foot of South Fifth St.

The use of the fixed platform proved entirely successful, and is believed to have been more economical than any other method that could have been proposed; and the results indicate that this method should have an extended application to problems of submarine boring. During the progress of the borings at this place, a new process for shutting off seams in bore-holes was successfully tried and much facilitated the work. This process was invented by Mr. Garvey, in charge of the diamond drill work of the American Diamond Rock Drill Co.; but details of the process have not yet been made public.

## HIGHWAY BRIDGES.*

By Carl Gayler.**

In preparing a paper on this subject I have endeavored to bring out a few points which might explain the very limited success of former agitations for an improvement in the building of highway bridges, and to discuss at some length the present practice, not of the highway bridge companies, but of the structural engineers who have made highway bridges a specialty.

It is now four or five years since the movement for a reform in the highway bridge business was at its height. The technical papers of that time are full of editorials and letters on this question; several prominent engineers and professors of civil engineering devoted their time and influence to it; the engineers' clubs of Chicago, St. Louis and Kansas City had committees appointed and reports adopted, and in several states drafts of proposed acts of legislature were prepared and came very near being introduced. And with this the movement came to an end, after having accomplished very little; and highway bridges are being built about in the same manner as before.

As there is no doubt that an improvement in the building of highway bridges is desirable, this failure is remarkable and seems to indicate that the fault lay with the proposed remedies. There is a good deal of force in the objections first raised by Mr. Horton, of the Western Society of Engineers, against the principal proposed remedy, i. e., legislative enactments. It seems unjust to transfer the control over highway bridges from the cities and counties to the state, as the former originate the work, pay for it and have to maintain it.

A perusal of what has been written and proposed at that time leaves, furthermore, the impression that the movement was not sufficiently comprehensive; it might be characterized as efforts to secure legislation providing for expert examinations of the strain sheets of proposed new highway bridges, and examinations of such old ones, the safety of which had given rise to doubts. But how about the preliminary work, deciding on the length of span, clear waterway, foundations, character of masonry, and—assuming the superstructure to be built according to the proposed state official's directions—the maintenance of the bridge? Surely, every one of these points requires the services of the bridge engineer. Counties will have to follow the example of our large cities, and employ capable engineers for their highway bridges. Wherever in cities and counties public works are in the hands of engineers, state supervision is unwarranted; where county commissioners rely on their own wisdom a limited supervision, as proposed at the time of the late reform movements, is insufficient.

Whenever one of the periodical unusually heavy rains flood a section of the country, we read about a number

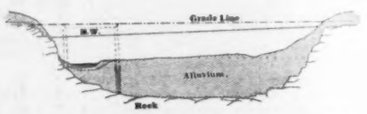



Fig. 1.—Typical Cross-section of a Stream Bed.

of bridges having been washed out; such occurrences are generally regarded by the profession with considerable equanimity, as if it were in the natural order of things that abutments and piers are underwashed, or superstructures carried away by floods which surely should never have reached them, whilst the occasional breaking down of a highway bridge is carefully noted, and still gives rise to spasmodic appeals for legislation. Why this important question of sub-foundations was never included in the efforts of the reformers, why it is likewise hardly ever mentioned in books and treatises on highway bridges, has always been a mystery to the writer. Some remarks on this subject may not be out of place.

The cross section of a valley, as shown in Fig. 1, through which a road is supposed to be built, requiring the crossing of a creek or stream, is typical with the cases with which I had experience; it is probably also typical of the greater number of cases in this part of the country. It is a broad valley, with steep banks and an alluvial bottom. The rock is near the surface on both bluffs, the alluvium extends down to considerable depth, and the water-course is near one of the two banks. A glance will show this valley to have been in former ages the bed of a great river, which, probably assisted by the action of ice, hollowed out its immense bed in the rocks. Subsequent sinking of the land or diminishing of the volume of water, or both causes combined, raised the level of the bed of the river, and the valley filled up with boulders, gravel or sand, or with clay, from the ice period, and, closer to the present water-course, with more recent deposits. To form an intelligent judgment of the contemplated foundations, an insight into the history of the valley in by-gone ages, assisted by some general

*From the Journal of the Association of Engineering Societies, June, 1906.
**Member of the Engineers' Club of St. Louis.

knowledge of geology, is necessary. Borings or test pits will complete what is necessary to plan the foundations and estimate their cost. The grading of the highway and the building of the substructure reduces the free waterway in time of floods, a deepening of the water channel, often, also, a shifting of the water-course, caused by the drying out of the vegetation, takes place, and these changes in the water-course are most important in designing the foundations, and, unless taken well into consideration, may cause the destruction of the bridge in short time. That this preliminary work, as well as the building of the abutments and piers, should be in the hands of the bridge engineer, will be readily conceded.

The superstructure of the American highway bridge has been developed by the highway-bridge companies, and it has been truly stated in regard to the best examples among them, that "greater strength and safety are obtained from a given amount of materials than with the methods of construction which prevail abroad." During late years, some of our leading structural engineers have given their attention to this subject, and have published books and specifications on highway bridges. A subdivision of the latter into three classes, according to their proximity to cities, assuming different live loads for each of them, is now the accepted rule. Being more familiar with Class I (or A), i. e., bridges in cities, I will confine part of the following remarks to this class:

It is generally agreed to assume for the live load, beside a concentrated load by which the dimensions of the flooring, stringers, floor-beams and hangers are obtained, a uniform load per square foot, covering the whole and portions of the bridge, ranging from 100 lbs. for short spans to 50 lbs. for longer spans. It is worth while to consider what this assumed uniform live load really means.

In the case of railway bridges the live load is simply the weight of the trains, and the unit strains in the truss members have been selected of such magnitude as to give a structure of reasonable rigidity. For the principal tensile members, 10,000 to 12,000 lbs. are customary, and for the compression members a reduction is made in the units according to the laws of the strength of columns. These unit strains are far lower than the elastic limit of the material would seem to warrant; they bear no relation to the breaking strength, and the so-called factor of safety may as well be abandoned as an antiquated expression without meaning; they have been evolved from the behavior of bridges under their daily duties. As Prof. J. P. Snow, in a recent discussion on the strength of iron railway bridges, puts it: "What is the basis of the present units? Examinations of bridges in service. In order that a bridge may be satisfactory it must remain rigid under trains and deflect but very little. These conditions can only be obtained by using low units." Now, with highway bridges, the case has just been reversed. We start out with unit strains borrowed from the railway bridge practice (increasing them, however, about 25%, for some reason not easily explained) and then choose the live load with the view of obtaining a satisfactory structure. It is well to keep this in mind; attempts to explain the customary live loads for highway bridges in any other way are misleading, if not dangerous.

Since the substitution of steel for iron, some engineers specify for highway bridges of the former material an increase in the unit strains of 20%. Granted that the ultimate strength of steel is 20% greater than that of iron, and the elastic limit even more, this increase in the units is, for the reasons stated above, not justified, as the modulus of elasticity of steel exceeds that of iron but little. By far the greater number of highway bridges, with their plank floors, are light structures; there is little mass in the metal to overcome the effects of the jolting of wagons over the rough planks, or of the trotting of horses; the vibrations are accumulative and we should be slow in adopting an increase of units. Increasing or doubling the units for the dead load should only be resorted to for very long spans, or for bridges with extremely heavy floors. I may be permitted to state here that my experience in this city with four steel spans of 120, 135, 150 and 220 ft. length, designed for the live load of Cooper's A, but for unit strains of iron railway bridges, no increase in them being made for units under dead load, has been such that I have never felt guilty of a waste of material in designing them, and that they have convinced me that the usual specifications for this class are too light.

Specifications and books on highway bridges and standard details for the same, as published in the latest works, have left the impression on the writer that this subject has not been treated with the conscientious care bestowed on other structural work. Whether the temporary and unsatisfactory character of most of the floors, or the fact that bridges built in accordance with these books and specifications are still far above the general practice all over the country, or the certainty that the bridges when completed will in nine cases out of ten be neglected and go to wreck and ruin anyway, can explain their neglect, I am unable to say.

The consideration of rigidity, which have led to the selection of these live loads, should be the guide in regard to lateral connections and the results of our experience with railway bridges should with equal care be applied to the highway bridge. In all through spans rigid connections of floor beams with posts and bottom chords should be insisted upon, not that perfectly safe hangers

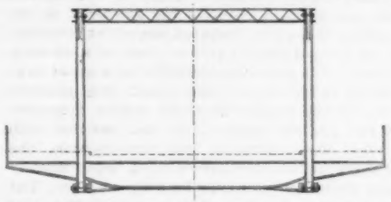


Fig. 2.—Cross-section of Bridge Truss, with Riveted Floor-Beam Connections.

could not be designed—the latter having even a slight advantage in applying the load centrally to the posts—but the gain in lateral stiffness is too great to be thrown away. It is impossible to prevent altogether a distortion of the structure in a storm or under a load applied close to one of the two trusses; but with deep floor beams well riveted to the posts and top lateral struts firmly attached to top and bottom of the top chord, as sketched in Fig. 2, considerable resistance is gained; with details as shown in Fig. 3, next to none.

There is one feature in through bridges to which full justice has never yet been done; it is the top lateral bracing. The universal custom is to design it to withstand the wind pressure (generally assumed to be 150 lbs. per linear foot of top chord). Now, there is not the least doubt that it should be made strong enough to resist the wind forces, but there is just as little doubt that if a bridge

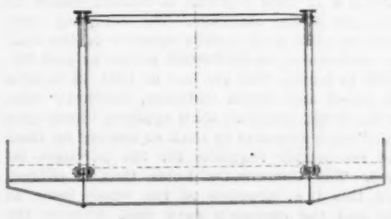


Fig. 3.—Cross-section of Bridge Truss with Floor-Beams Hung.

were thoroughly protected against wind, the top lateral system would still have to prevent the top chord from buckling; more than that, I am convinced that no storm ever strains it as the top chords do under their full duty. Anyone standing on a railway bridge with a train moving over it can satisfy himself on this point. It seems to be against sound judgment to design the top lateral system of a through span on the same supposition as the bottom lateral system of the deck span. This is one of the many instances where the strain sheet alone is no sufficient guide. The engineer has to use his experience and judgment to design a lateral system of sufficient rigidity; no theory in the world will enlighten him on the amount of lateral pressure exerted by an exceedingly long column. Mr. Waddell, in his book on highway bridges, states in this respect, without, however, entering into the question, that the top lateral rods in highway bridges up to 200 or 230 ft. length, if proportioned for wind pressure alone, are too light.

The above remark that the strain sheet does not cover every case applies with equal force to the specifications. It has been too much the custom to let highway bridges under a set of specifications, limiting the work of the consulting engineer—in case an engineer is consulted at all—to checking the figures and sizes. This custom, more than anything else, has made a highway bridge superstructure a mere merchandise. Nothing is, for instance, easier than to specify "a substantial railing" for a bridge, yet nothing is more indefinite and more difficult to enforce. Specifications are necessary, but we need even more the judgment of the engineer; we need more designing and less standards.

I have no intention of entering into the question of the relative superiority of pin-connected or riveted highway bridges, but there is one type in which the later are infinitely superior to the former, i. e., the short span pony truss. If designed with pin conections the lack of lateral stiffness is exceedingly difficult to overcome; with a riveted design we easily obtain a most excellent structure.

The subject of floor systems could easily be made to take up your whole time for an evening, and will not be discussed beyond calling attention to the new departure which has been occasioned through the advent of the electric motor car. That it will be of the greatest moment is apparent; we have in this city motor cars, weighing, when crowded with people, 24 tons, carried on two trucks 25 ft. apart; we have others of 18 tons weight when full of people, the trucks being spaced 14 ft. c. to c. In the first motor cars the load on each truck was distributed equally on both axles; to gain in tractive force the pin was then shifted so that about 75% of the load came on one axle, and in the latest cars (on Jefferson and Grand Aves.) the whole weight is carried on the driving axles. The first motors of 15-HP. have been succeeded by 25 and 50 HP. motors; girder rails, 6, 8 and 10 ins. deep have taken the place of the flat rail of the old street cars. It is not more than six years since electricity began to be generally applied to the city and suburban transportation, and it is not likely that the motor car, especially on long suburban lines with heavy grades, has attained its greatest weight.

Assuming now a bridge to be completed, the work of the engineer is still not over. In a few years the floor will need looking after, parts of the ironwork and railing require attention and the paint will begin to show those ugly spots which indicate that the work of deterioration has begun. This question of painting is the bane of the structural engineer's life, the one point where his knowledge is at fault and where his only recourse is to get the rust scratched off and new paint smeared over it. It does not matter very much what kind of paint he uses, iron oxide, lead paint or asphalt, so long as he tries to get a good brand and makes the most of his limited knowledge of the oil and the pigment; in all probability he will use them all in turns and in turns be disappointed. Protection of metal against atmospheric influences by paint applied cold is temporary. Rusting is most to be feared and most difficult to prevent on surfaces which are close together without being in close contact throughout, as at pin joints between the heads and eyebars and the adjacent portions of the posts and chords. Taking apart old pin-connected trusses we find the greatest corrosion on the sides of eyebar heads. It would not seem to be impossible to remedy this by filling these spaces with impervious material; to my knowledge this has been successfully done on the lower chords of the heavy Pauli trusses of the Monongahela bridge at Pittsburg. In riveted work there is no excuse for such dangerous spaces between different members, but we still find too often, through faulty riveting or where rivets have been spaced too far apart, that we can insert the blade of a knife between angles and plates, especially at the stiffeners of large web sheets.

Such weak points will probably never be quite overcome; the wonderful example of the Eads bridge, where the sides of the eyebar heads of the main arches and the adjacent sides of the joint blocks were planed and all the exposed joints of the covers of the tubes were carefully calked, will never be imitated, but the designer of structural work should keep this question always in mind.

The action of corrosion in wrought-iron work in cases where painting is utterly unavailing—and it has been my luck to have a number of such cases under my charge—is peculiar. A hard shell of corroded iron of pretty uniform thickness forms over the whole exposed surface; this shell scales off to make room for the formation of another shell, and this process goes on until nothing is left to scale off. It might not unreasonably be supposed that this process of scaling off in layers is peculiar to wrought iron as a material rolled and welded in layers, and that steel, being a homogeneous crystalline metal, would better resist the attack of rust. Should this prove to be true, what a splendid bargain did we make in exchanging iron for steel!

BIDS FOR TORPEDO BOATS were opened at Washington on Sept. 18. The proposals covered three 30-knot boats on builder's own plans and smaller boats of 20 and 22½ knots on both department and builders' plans. The prices bid were as follows:

| | 30-knot boats. Price for each, for One. | Two. | Three. |
|---|---|---|---|
| Union Iron Wks., San Francisco. | $227,500 | ..... | ..... |
| Bath Iron Wks., Bath, Me. | ..... | $194,000 | $180,000 |
| " " another proposition. | ..... | 235,000 | ..... |
| Herreshoff Company | 218,000 | ..... | 205,000 |
| J. H. Dialogue Co., Camden, N. J. | 260,000 | 255,000 | ..... |

| | 22½-knot boats. Prices for each, for One. | Two. | Three. |
|---|---|---|---|
| Columbian Iron Wks., Baltimore. | $79,000 | $79,000 | $79,000 |
| Moran Bros., Seattle, Wash. | ..... | ..... | 94,255 |
| Bath Co., Bath, Me. | ..... | ..... | 80,000 |
| " " for 3 25-knot boats. | ..... | ..... | 123,000 |
| Herreshoff Co. | ..... | ..... | 85,000 |
| " " Cushing design. | ..... | ..... | 92,500 |
| " " Cushing modified. | ..... | ..... | 78,500 |
| Wolf & Zwicker, Portland, Ore. | ..... | ..... | 75,100 |
| G. Lawley & Son, Boston, Mass. | 83,500 | ..... | 78,800 |

| | 20-knot boats. Price for each, for One. | Two. | Three. |
|---|---|---|---|
| Columbian Works. | $49,000 | $49,000 | $49,000 |
| " " on their own design | 45,000 | 45,000 | 45,000 |
| Moran Bros., Seattle. | 59,640 | ..... | 56,928 |
| Herreshoff Company. | 40,000 | ..... | 37,500 |
| Wolf & Zwicker, Portland. | ..... | ..... | 45,000 |
| Providence Steam Engine Co., R. I. | ..... | 51,600 | 48,650 |
| Lewis Nixon, Elizabeth, N. J., on his own design. | 69,000 | ..... | 68,000 |
| C. Hillman Ship & Eng. Co., Phila | ..... | 48,000 | ..... |
| J. H. Dialogue Co. | ..... | 58,500 | ..... |
| G. Lawley & Sons, own design. | 61,500 | ..... | 54,835 |

The proposals were much complicated, by combinations of classes and by alternate designs of several types. These will have to be carefully examined before any award can be made. The bids were in the main reasonable and the number of bids gives general satisfaction.

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AND
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Immediately upon the heels of an announcement that the New East River Bridge Commissioners would receive proposals for constructing the foundations of the New York tower, on Oct. 7, comes a statement that work will probably be delayed owing to a lack of funds. The work contemplated is to cost approximately $500,000, and this official, "high in authority in the Commission," says that this money is not on hand, and they do not know when it will be available. The late advertisement for bids for bonds brings out the unpleasant fact that $50,000 of the bridge bonds recently offered by Controller Fitch are yet unsold, and the $100,000 previously disposed of were taken by the Uhlmann syndicate and paid for with a portion of the money received by that syndicate in return for the right of way. Both New York and Brooklyn are having difficulty now in advantageously disposing of their bonds, and until the financial horizon clears up somewhat the sale of $15,000,000 bridge bonds, upon which construction depends, is problemetical, to say the least.

In the purchase and laying out of plant on large construction works, it is comparatively rare to find much consideration given to the questions of efficiency and economy in operation, the general impression being that the temporary character of the work, the shifting of the plant during the work, and the rough handling to which the plant is subjected, make it not worth while to go to much expense to secure economical operation. This is no doubt true to some extent, especially on smaller jobs, though even in such cases gross and unnecessary waste and inefficiency (with consequent increased expense and reduction in profit) are too often evident, owing in general to the failure of the contractor or his subordinates to see the relation between an inefficient or badly handled tool or machine and the net financial results of the work. On large works, however, where large sums of money are involved, where a considerable amount of plant is required, and which will continue for many months or even years, it is manifestly to the contractor's interest to carefully consider the most efficient and economical plan of operating his plant, taking into consideration the conditions under which it will be worked. In another column of this issue we describe at some length the compressed air power plant and power transmission system installed for operating the tools and machines on the Jerome Park reservoir contract, a piece of work which involves an expenditure of about $5,500,000, and will extend over nearly seven years. Instead of having a number of small steam boilers scattered over the work, which is the common arrangement on construction contracts, there is one central power plant, which requires the attention of but two men and may be operated almost as economically as the permanent power plant of a factory. The result will almost necessarily be a great saving in fuel as compared with a plant using separate boilers, as the numerous small boilers generally employed are not adapted for nor handled with any view to economical fuel consumption, the main thing in the attendant's mind being usually to keep the steam up to the blowing-off point. The pipe line transmission system is very flexible and can be shifted and extended to reach any part of the work with little trouble or expense. We believe this is the first case in which compressed air power transmission has been employed on any such extensive scale for contract work, and it certainly seems to be well adapted for the conditions under which it has been established.

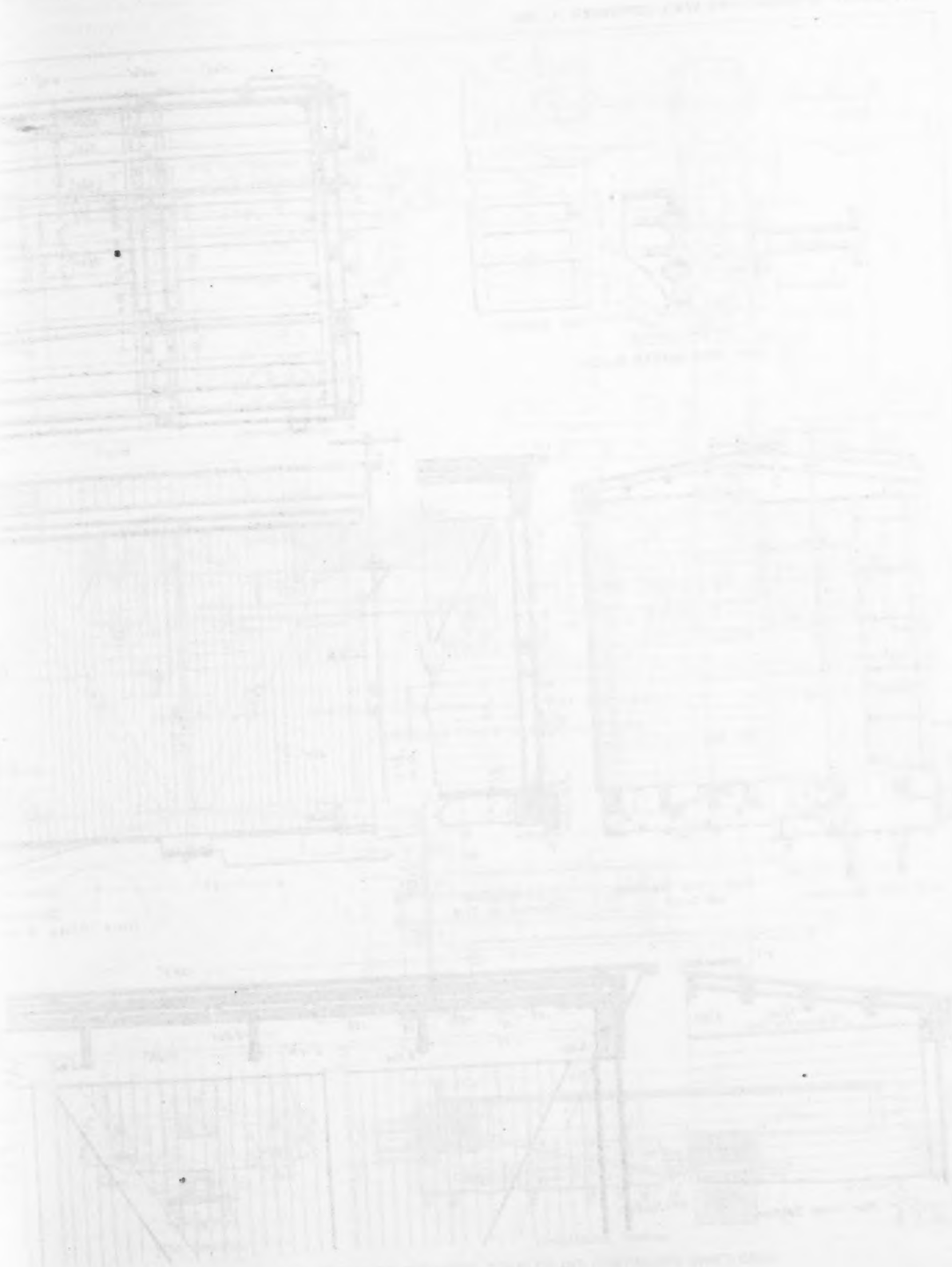
An interesting question connected with the launching of corporations and the early marketing of their stocks and bonds came up in the late hearing of the Maritime Canal Co. before the Massachusetts Railway and the Harbor and Land Commissions. This company was incorporated by the last Legislature to build a ship canal across the Cape Cod peninsula, and the act stated that the issues of stock and bonds should be subject to the law of 1894 relating to similar issues by street and steam railways. The company petitioned that the joint boards approve of the total issue authorized, or $6,000,000 in stocks and $6,000,000 in bonds. But the law of 1894, in dealing with street and steam railways, distinctly says that the Commissioners shall approve "from time to time" such amounts as shall be deemed by them to be reasonably requisite for the purposes intended. The Commission holds that it cannot, under this law, approve of the whole issue at once; and the company says that without the whole of the issue to put up as collateral they cannot raise the money necessary for the work; and here the matter rests. Ex-Governor George S. Boutwell, in arguing the case of the Maritime Company, contended that this was an enterprise entirely differing from a railway; that the projectors could not go into the market for subscriptions, but that bonds must be sold in such a way that the issues will go hand-in-hand with the enterprise. Contracts must be made with contractors for the whole issue, or the canal would never be built. He also explained that the contracts were to be paid for in stocks, and the stock and bonds would be issued to pay for work done on the engineers' certificates. Chairman Sanford of the Railway Commission, held that the law applied in this case and the Commissioners could not say at this time that $12,000,000 was a reasonable amount for the total issue. Mr. Sanford held that if the stocks and bonds were thus approved by the Commissioners, they would go to the contractor who would sell them to the public with the board's approval upon them, and market them mainly upon this approval. Nor would he consent to approve of the issue of $250,000 of stock and $250,000 in bonds, which the petitioners finally asked for to pay for preliminary surveys, for the reason "that there was not one cent's worth of property to secure these bonds;" and he suggested that if the promotors had the faith in their enterprise which they professed, they should raise this necessary $500,000 among themselves. But even if they did this he would not advocate the approval of the entire issue, but would do as the law prescribed.

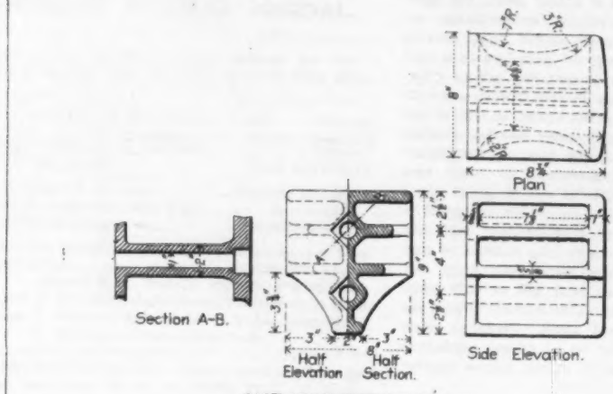
To the average promotor this is a new and most objectionable manner of handling an issue of stocks and bonds. Under former and well-established usage it was the general public, and not the promotor, who took all the financial risk of any similar enterprise; and it was the business of the "construction company" to place the issues where money could be obtained for them—and to reap the profit, if any profit there was. Massachusetts is far in advance of other states in her laws regulating the marketing of bonds by railway and other public corporations and in her attempts to regulate a privilege too often abused. The law of 1894 may be annoying to those managing certain enterprises of this character in compelling them to resort to new methods of raising the preliminary funds required; but its tendency will also be to eliminate projects depending more or less upon chance for success, and also to lessen the amount of money sunk by the public here and abroad, in investments of doubtful merit. It is true, that no one can foresee the outcome of every enterprise of large dimensions, nor can any one tell whether it will ultimately be a profitable or a losing affair. But it is time that the investors of this country took fewer chances than in the years past; and any laws should be welcome that tend to lessen these chances by placing more responsibility upon the promotors of an enterprise and by establishing honest and intelligent supervision over the preliminary stages of undertakings that are ultimately to cost millions.

The new open-hearth process of steel making, described on another page of this issue, is really only a moderate variation from present current practice; but the results obtained, amounting to a reduction in the cost of conversion of over one-fourth, make the process deserving of study. The many improvements in open-hearth work which have been introduced during the past few years, among which we may note especially the American tipping furnace, are tending all the time to reduce the cost of open-hearth work and to make it more similar in economy and enormous output to work with the Bessemer converter.

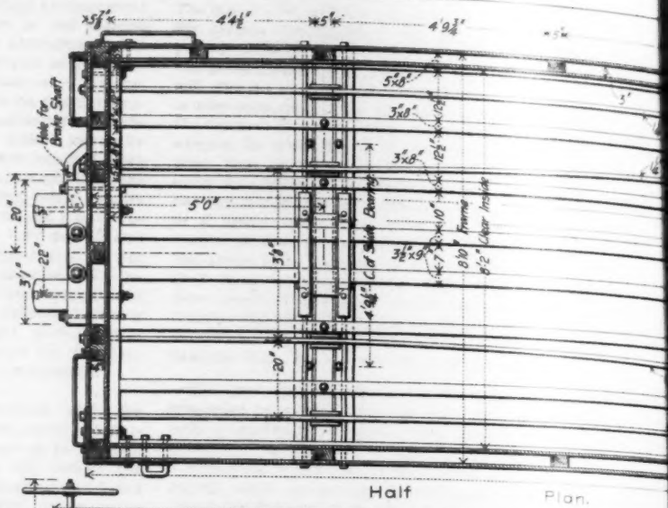
### EFFECT OF THE RATE OF COMBUSTION UPON THE EFFICIENCY OF STEAM BOILERS.

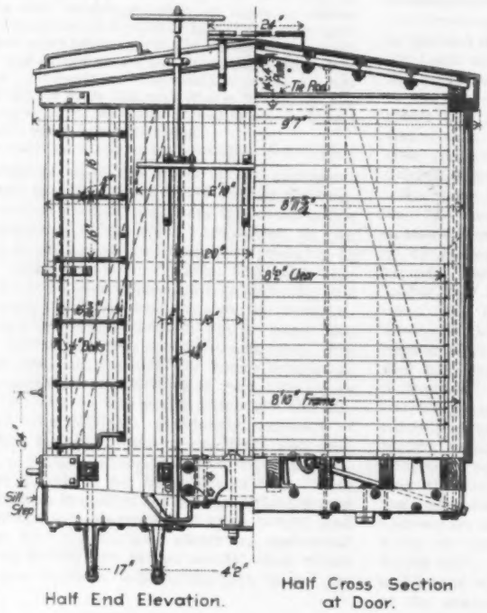
The paper of Prof. W. F. M. Goss, published elsewhere in this issue is an important contribution to our knowledge of the effect of high rates of combustion upon the efficiency of locomotive boilers. It has long been known that if there is no change in the ratio of heating to grate surface in a steam boiler an increase of the rate of combustion beyond a certain limit (which limit is somewhere in the neighborhood of that required to produce an evaporation of about 4 lbs. of water per sq. ft. of heating surface per hour), will make a decrease in economy. One of the causes of this decrease is clearly revealed in the increase of temperature of the chimney gases which is commonly found when the boiler is driven beyond the rate named—and is the insufficiency of the heating surface to abstract the heat generated in the furnace. In such a case the decrease of economy is not due strictly to increasing the rate of combustion on the grate, but to the generation in the furnace of a total quantity of heat so great that the heating surface of the boiler is not capable of absorbing as great a percentage of it as it does when the amount of heat generated is less. The question has often been raised whether a high rate of combustion of itself is not favorable to high economy. For example, suppose a certain stationary boiler to have a ratio of 30 sq. ft. of heating surface to 1 sq. ft. of grate surface, that 15 lbs. of coal are burned per hour per sq. ft. of grate, and that 4 lbs. of water are evaporated per sq. ft. of heating surface, equivalent to an evaporation of 8 lbs. of water per lb. of coal, might not the economy be improved by cutting down the grate surface one-half, making a ratio of 60 to 1, and by increasing the force of the draft so as to burn the original quantity of coal on the reduced grate, that is to burn it at double the original rate, or 30 lbs. per sq. ft. of grate? The answers to this question in hitherto have shown quite a difference of opinion, but the tendency in recent years, especially among those experienced in the use of bituminous coal, seems to be toward a belief in the greater efficiency of high rates of combustion on a relatively small sized grate, that is with a high ratio of heating to grate surface. The experiments of Prof. Goss give no definite answer to this question as far as stationary boilers, with rates of combustion ranging from 10 lbs. to 40 lbs. per sq. ft. of grate are concerned, but they do show some of the reasons why in lo-

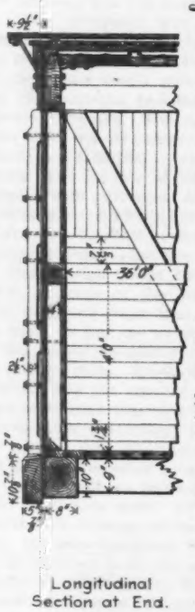


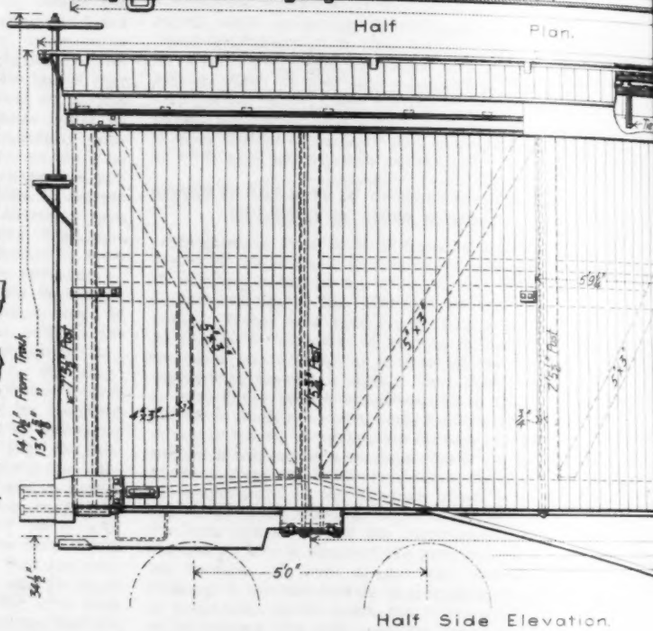


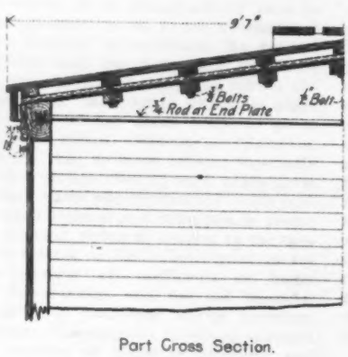

CAST IRON BUFFER BLOCK.

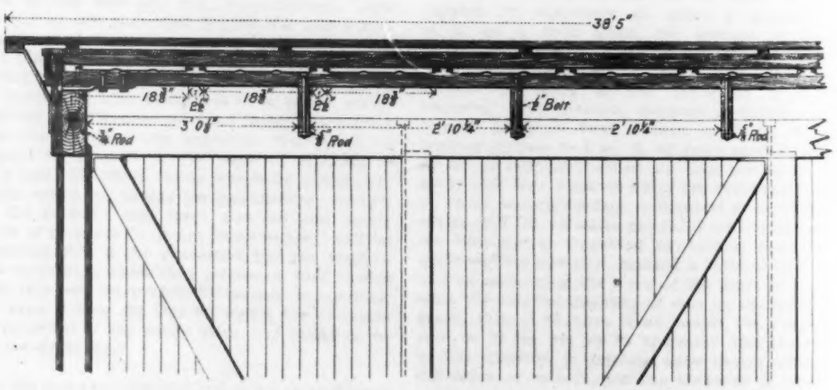


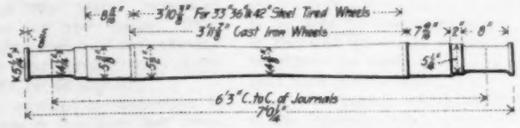



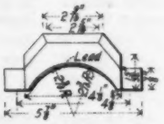

ELEVATIONS AND SECTIONS OF CAR.

**STANDARD BOX CAR OF 60,000 POU**

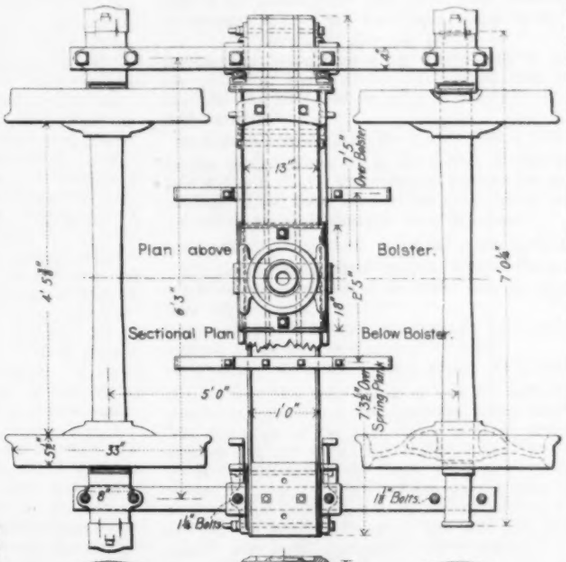
**Harvey Middleton, General Superintendent of Motive Powe**

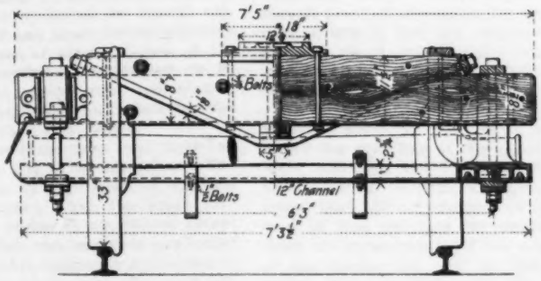



Elevation of Axle.

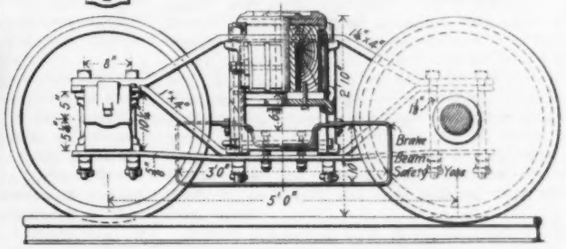



Journal Bearing.



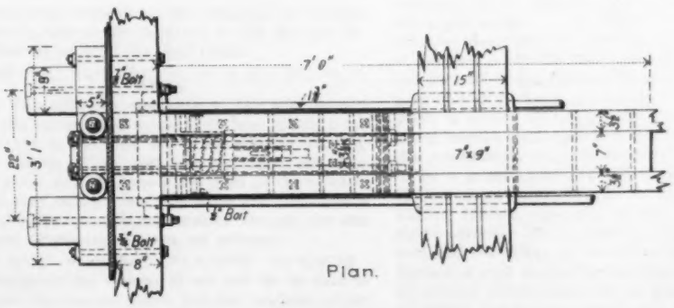




Half End Elevation. Half Section through Bolster.

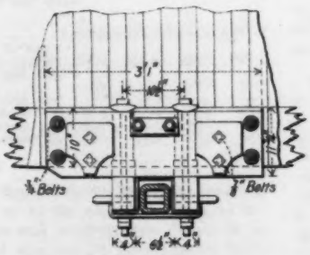



Half Side Elevation. Half Section through Bolster.

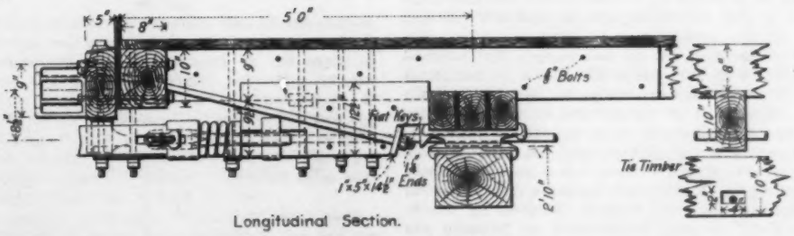
STANDARD TRUCK FOR FREIGHT CARS.




Plan.

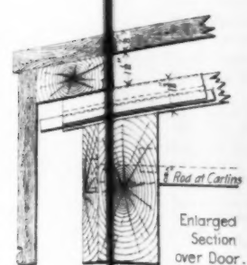



End Elevation.




Longitudinal Section.

CONNECTION OF AUTOMATIC COUPLER AND CONTINUOUS DRAFT GEAR.

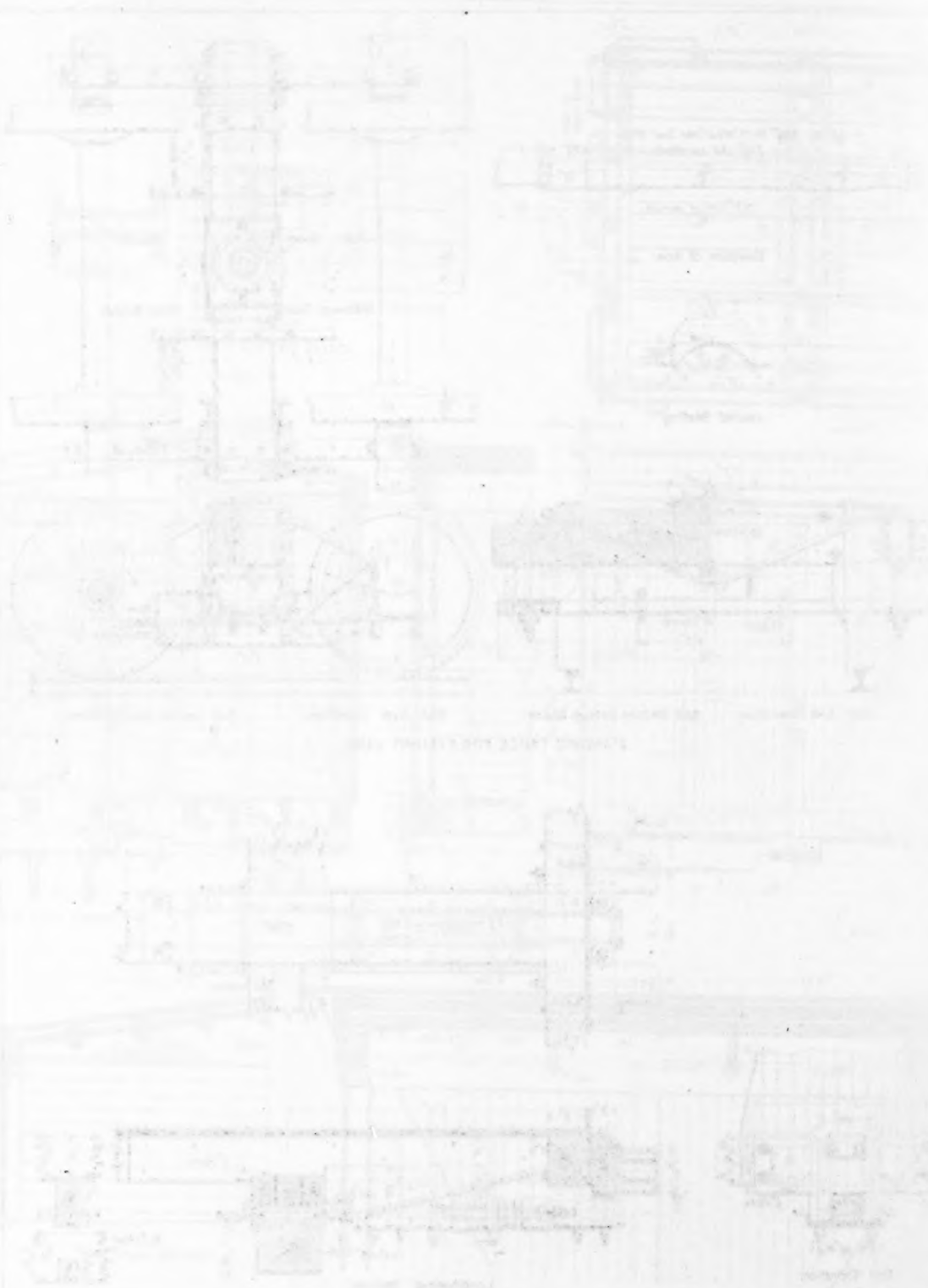


Fastening for Ends of Metal Roof Sheets.

000 POUNDS CAPACITY; BALTIMORE & OHIO R. R.

tive Power. E. W. Grieves, Superintendent of Car Department.

CHAS. HART & SONS, LITH., 88 VESEY ST., N. Y.



comotive practice very high rates of combustion tend to decrease of efficiency. His experiments were with four different rates of combustion; viz.: approximately 60, 80, 120 and 240 lbs. per sq. ft. of grate per hour, the grate surface being cut down in the tests after the first respectively to ¾, ½ and ¼ the full size, so as to make the total amount of coal burned per hour approximately the same in each of the four tests. The results of the tests, expressed in terms of efficiency of the boiler, 100% representing perfect efficiency, or the absorption by the boiler of the total heating value of the coal, were respectively 61, 59, 56 and 50%.

Prof. Goss makes an attempt to determine to what the increased losses in the three last tests, as compared with the first, were due. The total amount of coal burned, and presumptively the heat generated in the furnace, in each case being the same in each of the four tests, the question of possible deficiency in extent of heating surface is eliminated. The possible conditions which may cause the decreased economy with increased rate of combustion are thus apparently narrowed to these three; viz., 1, imperfect combustion of the coal; 2, excessive air supply beyond that required for proper burning of the coal; 3, loss of coal in the sparks blown out of the smokestack. The investigation as to the effect of the first two of these conditions was made by analyzing the gases, and as to the third by weighing the sparks collected in the smoke box and those discharged from certain selected portions of the total area of the top of the stack which are considered to be representative of the whole area, calculating therefrom the total spark loss, and analyzing the sparks to determine their heat value.

The result of these investigations Prof. Goss has graphically shown in Fig. 2 of his paper. The greatest source of loss by high rates of combustion in ordinary practice, when the grate surface is not cut down, is due to insufficient extent of heating surface. When this source is eliminated by cutting down the grate surface in proportion to the increased rate of combustion the next important source of loss is in the sparks blown into the smoke box and out of the stack. With about 6,500 lbs. of coal burned in each of the four tests, the total amount of sparks lost was respectively 369, 571, 772 and 1,058 lbs., the loss increasing as the rate of combustion increased.

Prof. Goss's diagram, and also the text of the paper, show that he considers that the losses due to imperfect combustion and to excessive admission of air increased with the increased rate of combustion. With this statement we regret to be compelled to take exception, and to say that it is not proved by his data. On the contrary, his results appear to us to indicate that with the reduced grate surface the only loss which increases with the rate of combustion is the spark loss, which is serious enough, and that the loss of efficiency due to excessive admission of air or to imperfect combustion was practically constant in all four of the tests. In support of this opinion we have the following data:

| Test No. | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Lbs. of dry coal fired | 6,443.0 | 6,522.0 | 6,514.0 | 6,227.0 |
| Lbs. coal equivalent in heating value, total w't. sparks | 277.0 | 457.0 | 664.0 | 963.0 |
| Total heating value coal lost in sparks, % | 4.3 | 7.0 | 10.2 | 15.5 |
| Total heating value coal absorbed by water in boiler, % | 61.4 | 58.5 | 55.9 | 49.6 |
| Sum of the last two items | 65.7 | 65.5 | 66.1 | 65.1 |
| Loss, efficiency, all causes,* % | 34.3 | 34.5 | 33.9 | 34.9 |

*Other than sparks.

The last line of figures shows the total loss due to heat carried away in the chimney gases, to imperfect combustion and to radiation. There is no evidence here that any one of these losses tends to increase with an increase of rate of combustion, for the differences between any two of the four figures given above are well within the limits of error of the observations. If our view of the matter is correct, then the diagram, Fig. 2, given by Prof. Goss, should be modified by causing the triangular area a d e, which he says represent the extra loss by driving the rate of combustion above 50 lbs. per sq. ft. of grate per hour, to disappear, and the line a d to become horizontal.

Prof. Goss calls attention to the great excess of air passing through the fire in the third and fourth tests, and says "it would appear that this cause must have operated to reduce the performance of the boiler as the rate of combustion is increased." He also says that the presence of carbon monoxide (C O), which occurs in the fourth test only, is accepted as proof of imperfect combustion. Undoubtedly either a great excess of air supply or the presence of carbon monoxide in the chimney gases would be accepted, if they were conclusively shown by the analyses of the gases, as accounting for loss of economy. These two causes of loss are, however, usually supposed to be antagonistic to each other, that is it is supposed that both cannot take place at the same time, excessive air supply will preclude the finding of C O in the chimney gases, and the finding of C O is in itself proof of an insufficient air supply. Nevertheless Prof. Goss's chemist has found C O in the fourth test only, in which the air was in greater excess than in any other of the tests. Attempting to account for this Prof. Goss has recourse to a theory of Herr R. Ernst, that C O is formed under very high rates of combustion, "or more specifically when the temperature of the fire is above 1,800° F." We have looked up the reference to this theory given by Prof. Goss, and find it only in the shape of an editorial in "The Engineer" (London) of Aug. 4, 1893, which gives no details of the experiments upon which Herr Ernst based his theory. In the absence of the experimental proof of the theory we must decline to accept it, and in fact the editorial referred to appears to us to contain more rank heresy on the subject of combustion than we had ever before seen.

We have a theory of our own to explain the analyses given by Prof. Goss, and that is that either the sampling of the gases or the analyses were incorrect, and for proof of this we submit the following calculation: Prof. Goss correctly states that "all air admitted to the furnace in excess of that required for combustion is heated from the temperature of the atmosphere to that of the smoke box, and by this process heat is taken from the furnace." The analyses of the gases give us the data by which we can obtain the amount of air supplied to the fire per lb. of carbon. The formula is

$$\text{Lbs. of air per lb. carbon} = \frac{4}{3}\left[\frac{2(CO_2 + O) + CO}{CO_2 + CO}\right] \div 0.23.$$

Applying this formula to the analyses we obtain for the amount of air supplied to the fire per lb. of carbon in each of the four tests:

No. 1, 38.4 lbs.; No. 2, 33.5 lbs.; No. 3, 46.9 lbs.; No. 4, 102.5 lbs.

Since the ultimate analyses of the coal is not given, we cannot say accurately how much total carbon was in the coal, but if we assume that 5% of the weight of the coal was hydrogen, nitrogen and oxygen, and that the remainder of the volatile matter was carbon, we will have the percentage of total carbon in the coal nearly enough for the purposes of the calculation, as follows:

No. 1, 84.9% No. 2, 85.8% No. 3, 85.0% No. 4, 85.4%

Multiplying the weight of air per lb. of carbon by these figures we have for the weight of air per lb. coal burned:

No. 1, 32.6 lbs.; No. 2, 28.7 lbs.; No. 3, 39.9 lbs.; No. 4, 87.5 lbs.

But this calculation assumes that all the carbon in the coal was burned, whereas the fact was that a considerable portion escaped in the form of sparks, and a small portion, according to the analyses in the shape of heavy hydrocarbon. If we take as the percentage of this carbon loss the percentage of loss of heating value in the sparks, a close enough approximation, we will have for the carbon actually burned, expressed as a percentage of the total weight of coal:

No. 1, 80.6% No. 2, 78.8% No. 3. 74.8% No. 4, 69.9%

and for the weight of air supplied to the fire per lb. of coal used

No. 1, 31.0 lbs.; No. 2, 26.4 lbs.; No. 3, 35.1 lbs.; No. 4, 71.6 lbs.

The weight of gases per lb. of coal used would be the same as the weight of air plus the weight of the combustible portion of the coal which entered into the gases, or approximately,

No. 1, 31.9 lbs.; No. 2, 27.2 lbs.; No. 3, 35.9 lbs.; No. 4, 72.3 lbs.

The loss of heat in the gases passing out of the stack is the product of their weight into their average specific heat (say 0.24) into the difference between the temperature of the smoke box and that of the atmosphere (say 60°). The difference of temperature in the four tests respectively is

587°, 569°, 550° and 440° F.

Multiplying these figures by the weight of gas per pound of coal and by the specific heat we have for the heat loss, in units of heat per lb. of coal burned,

No. 1, 4,493. No. 2, 3,814. No. 3, 5,139. No. 4, 7,635.

As the total heating value per pound of dry coal was 13,000 B. T. U., these figures give as the percentage of the total heat of the coal, which was lost in the gases discharged from the stack,

No. 1, 34.6% No. 2, 29.3% No. 3. 39.5% No. 4, 58.7%

We have already found that the sum of the heat absorbed by the water in the boiler and the spark loss was

No. 1, 65.7% No. 2, 65.5% No. 3. 66.1% No. 4, 65.1%

Adding these figures together we have

No. 1, 100.3% No. 2, 94.8% No. 3. 105.6% No. 4, 123.8%

No account has been taken of loss by radiation, which, if obtained, would increase these figures. The meaning of the last figure is that without considering the losses by radiation and by imperfect combustion the heat absorbed by the boiler, that lost by unburned sparks, and that lost in the gases discharged from the stack, accounts for all the heating value of the coal and 23.8% more. The most reasonable explanation of this absurd result, it seems to us, is that there was something wrong with the analyses of the gases.

The results of these four tests, as we read them, are valuable in showing that the efficiency of this particular locomotive is reduced only from 61% to 50% by increasing the rate of combustion from 60 to 240 lbs. per sq. ft. of grate per hour, and that the whole of this loss of efficiency is due to the loss from sparks, which loss increased from 4% to 15% of the total heating value of the coal used.

It does not appear from these tests that rapidity of combustion has any bad effect upon the combustion itself, or any bad effect whatever, except that when the rate of combustion is high sparks are more apt to be driven out of the stack. There appears to us to be no reason why very rapid driving should make any difference in the economy, other than the loss by sparks, provided the grate surface is cut down proportionately to the increased rate of driving, and the thickness of the bed of fire is proportioned to the speed of the current of air passing through it. This thickness of bed is really the most important element. With a given air supply if the fire bed is too thick, carbon monoxide will be formed; if too thin, the combustion may be perfect, but there is apt to be a great excess of air, which will cause an excessive amount of heat to be carried up the stack. With a thin bed of coal and a very low draft pressure there may be perfect combustion and not too great an excess of air. With a very thick bed and with a strong draft there may also be perfect combustion and no great excess of air. Opposite conditions, thick fire bed with strong draft and thin fire bed with light draft, may produce identical results as far as economy is concerned. Whether in any particular case a high rate or a low rate of combustion should be adopted will depend not on the theoretical consideration of which will insure the most perfect combustion, but on other circumstances which relate entirely to convenience or to practice. In stationary boilers low rates of combustion may be adopted with the best results, but if a low rate means too long a fire grate for a fireman to fire properly, then a higher rate with a shorter grate should be adopted. Higher rates of combustion are adopted on locomotives than in stationary boilers, not because they give more perfect combustion, but because they cause the boiler to generate steam in sufficient quantity. Prof. Goss has shown that the spark loss limits the rate of combustion which may be used without great loss of economy. If there was any possible way of returning the sparks to the furnace, there seems to be no reason why still higher rates than any he has tried might not be adopted. In a blast furnace for making iron, as much as 15 tons of coal

per hour may be burned, the total area of the zone of combustion not exceeding 30 sq. ft. This is equivalent to a rate of combustion of over 1,000 lbs. per sq. ft. of sectional area per hour, or about five times the highest rate used in locomotive boilers, and more than fifty times the usual rate in stationary boilers. If any necessity should arise for burning 1,000 lbs. of coal per sq. ft. of grate area per hour under a steam boiler it might be done without sacrifice of economy if only proper procession could be made for getting rid of the ashes and for preventing loss by sparks. High rates of combustion of themselves do not mean imperfect combustion, undue excess of air, or loss of economy, nor do they mean the reverse. Their use is therefore permissible if circumstances require.

In the case of locomotives there is an additional cause of loss of economy by high rates of combustion, besides the spark loss, and that is that these high rates require increased draft, which is only secured by increased back pressure in the cylinders of the engine. In the four tests by Prof. Goss the draft pressure was respectively 2.2, 2.5, 3.3 and 5.6 ins. of water. It is probable that indicator diagrams from the cylinders would show that the loss of power in the engine due to the increased back pressure required to provide the strong draft amounted to quite an appreciable percentage of the total power developed.

## LETTERS TO THE EDITOR.

### Driving Logs Upstream.

Sir: In your issue of Sept. 10 information is asked with reference to "driving" logs upstream. An old "shanty" foreman, Wm. Scott, tells me that though very unusual this has been done. His experience was on Deep River, a tributary of the Ottawa, the distance over which the logs were moved was comparatively short. A line was let down stream to which ring "dogs" were attached, two to each log. Each log butted closely to the preceding one and this log "snake" was drawn up the stream by a sort of crab capstan. The chief feature is that the current only impinges on the butt of the leading log. Assembling the "tow" is somewhat difficult as is also the withdrawing of the "ring dogs." These consist of a flat spike with a loose ring normal to the plane of the knife-shaped blade. I remain, yours, etc.

C. R. Coutlee.

Cascades Point, Quebec, Sept. 19, 1896.

### A Cheap Bridge.

Sir: I send you herewith a photograph which, I think, may be of interest to your readers as an unique and efficient structure of very low cost. The severe freshet of last spring washed away the bridge over the Little Androscoggin River at Snow Falls in the town of Paris, Me., and this bridge was built by me for the town for

**Temporary Foot Bridge over Little Androscoggin River, at Snow's Falls, Maine. Span between Towers, 40 ft.**

a temporary foot bridge pending the erection of the new structure. The fir-balsam logs were cut in the adjacent woods and strung across the gorge; towers were built on each bank of hemlock logs; and cables of twisted wire fence ribbon were passed from anchorages on either bank over the towers and under pieces of iron pipe passed under the stringers. One anchorage is shown in the photograph, the wires being nailed to a timber braced under the bracket of an old boiler, while the other ends are fastened to the bottoms of tree trunks. The wires were drawn tight by means of the usual fence stretchers in use by farmers. A few old planks, which did not follow the bridge down stream made the floor, and rails were found within a few feet. I did no figuring of strains, the work being hastily contrived, but I was satisfied by seeing the bridge sustain, without noticeably deflecting, a load of a little over 500 lbs. concentrated at the center.

The cost of this bridge was almost entirely in labor, the material, with the exception of the fence ribbon and a few pounds of nails and spikes, being picked up in the immediate vicinity, the items being as follows:

| | |
|---|---|
| 26 lbs. twisted wire fence ribbon @ .04 | $1.04 |
| 1 lb. staples | .10 |
| 1 lb. 50d. spikes | .05 |
| 1 lb. 10d. nails | .04 |
| Labor, men and oxen | $10.50 |
| Total | $11.73 |

Yours very truly, Fred. J. Wood.

Snow Falls, Me., Sept. 5, 1896.

### Another Stadia Rod.

Sir: I enclose herewith a sketch of a self-reading long-distance stadia rod, which I designed for use on the preliminary survey for the "Kern River & Los Angeles Electric Power Company."

Rod Marking.

**Self-Reading, Long-Distance Stadia Rod, used on Preliminary Survey for the Kern River & Los Angeles Electric Power Co. Designed by Burr Bassell, C.E.**

This rod was used for the entire distance of about 108 miles, crossing desert and mountains (both for stadia distances and vertical angles), and gave entire satisfaction. It cost a little less than $5 and was as serviceable at the end of the survey as at the beginning.

The criticism may be made that one cannot read close or fine enough. In actual work it was found that the rod could be easily read at long distances to 1-20 of an interval (representing 5 ft. with a 1-ft. interval, or 2½ ft. on the rod used on abovementioned survey), and since the errors are not cumulative, but, as in leveling, tend to balance each other, very good work was done.

Permit me to call attention to the graduation, which must be studied and used to be fully appreciated.

There are no numerals excepting at the stadia wire intervals (for 100 ft.), The half intervals marked by double diamond figures are exceptionally clear to read at long range. The circular dart at each numeral alternate to right and left side of rod—the right hand being opposite left hand opposite the odd. even numerals and the This lessens the liability to err in reading, when rod is partially hid from view.

I am well aware that almost every engineer has his "pet rod." If you think this worthy the space in your valuable paper, you are welcome to use it. I claim the following for this rod: (1) Simplicity and ease of reading. (2) Cheapness and facility of transportation over rough mountainous country. (3) Durability.

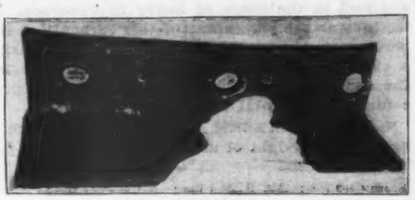
Yours truly,

Los Angeles, Cal., Aug. 31, 1896. Burr Bassell.

### A Bridge Angle Iron Melted by Lightning.

Sir: I send you herewith a photograph of a piece of angle iron recently taken from a railway bridge over a street in Lowell, Mass. It was evidently melted by lightning, although no one knew that the bridge had been struck until the damage was discovered by the bridge inspector in making his periodical examination.

The bridge is in one of the freight yards at Lowell and a switchman is stationed very near one end of it, but he



**A Bridge Angle-Iron Melted by Lightning.**

was unaware that lightning had visited his vicinity. This bridge carries five tracks on four pony trusses. Four of these tracks are used by regular passenger and freight trains and one, where the damage occurred, for yard shifting only.

The angle iron in question was in the top flange of a floor beam under this side track; the flange being made up of two 3½ × 3½ × ⅝-in. angles. The rail crossed the floor beam directly over the place burned out and about 2¼ ins. above it. Half of the rail base for a space of about 6 ins. and part of the thickness of the web was melted, a hole about 4 ins. in diameter was burned through the 1-in. board floor and the hard pine tie lying against the edge of the floor beam flange was charred into about 1 in. The paint was burned off clean over a space about 1 ft. in diameter below the burned angle, but was not affected on the other side of the floor beam web. There was no further trace of the current.

A double track electric line passes under this bridge with overhead trolley wire attached to the ironwork by insulated connections. One of these wires passes about 6 ft. from the point of the bridge attacked, but there is no evidence of the current traveling to the wire and there is no record in the office of the electric road of any disturbance to the wires or the insulation.

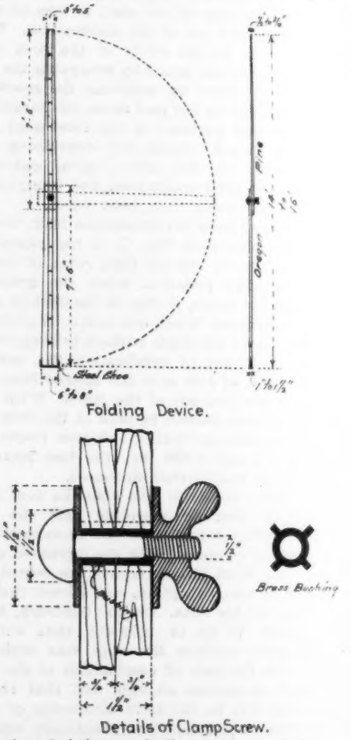
Yours truly, J. P. Snow,

Bridge Engineer, Boston & Maine R. R.

Boston, Sept. 5, 1896.

### Subjects for Theses on Municipal Engineering.

Sir: Will you kindly suggest some lines of investigation in matters pertaining to municipal or sanitary engineering that would furnish subjects for theses? Subjects that




Folding Device.




Details of Clamp Screw.

Interval between digits 1 foot, or distance intercepted by stadia wires with the rod 100 feet from instrument.
Vertical thickness of figures and bars 1/10 the interval between digits.
Width of digits 2/10 or 1/5 of the interval.
Height of digits 7/10 of the interval.

**Details of Stadia Rod.**

advanced students might deal with in a manner to be of value to the profession, in the time usually allowed for thesis work in the best colleges of civil engineering.

Yours, etc., X. Y. Z.

Ithaca, N. Y., Aug. 31, 1896.

(There is no end to the list of municipal and sanitary engineering subjects which need careful investigation, although it may not be easy to name many which are in every way suitable to college thesis work. The truth of the matter is, though, that more depends upon the way the college student handles his subject than upon what he chooses. We give a few subjects, more in the way of suggesting other, allied ones, or modifications of these, than with the idea of finalities, as follows:

(1) Sewer flushing, with special reference to the efficiency of automatic flush tanks.

(2) Paving materials: Not an attempt to cover

the whole subject, but a careful study of some phase of it, or some particular material, based on experiments by the author as well as the results of actual practice.

(3) Water rates, including the proper method of distributing the cost of water between private consumers and the general public.

(4) Dams and reservoir failures; actual incidents with their causes and lessons.

(5) Studies of actual typhoid epidemics in relation to water, milk and food supplies. As the epidemics taken up should be such as had not been carefully investigated, and would need to be studied while actually in progress, the availability of this subject would be uncertain in any particular case.—Ed.)

### Testing Steel Tapes.

Sir: Kindly state the standard temperature and pull at which steel tapes (100 ft.) are correct; whether the tape is suspended or laid on a level surface; the practice of the U. S. Government in these particulars; and the standard temperature at which steel bridges are laid out in the shops or at which they have their correct length.

Respectfully, Oscar Erlandsen,
Assoc. M. Am. Soc. C. E.

136 Liberty St., New York, Sept. 15, 1896.

(By applying to the U. S. Coast and Geodetic Survey, Washington, D. C., our correspondent can obtain a copy of Bulletin No. 15, issued in 1889, describing the U. S. Bench Standard, by which the errors of tapes are determined. It is there explained that an iron bar, 100 ft. long, has been selected in preference to a wall standard, as in the latter case the effect of temperature on the wall is difficult to ascertain. The material in the tape and bar is also so nearly identical that temperature observations are almost, if not quite, unnecessary. One end of the tape is secured to this bar and laid out flat upon the bar, so that it quickly reaches the same temperature. The tape is then stretched by a spring-balance, sensitive to a half-ounce, and the usual pull is 12 lbs., and this pull is stated in the certificate given by the Bureau. Inserted in the bar are two parallel series of German silver plugs, on the polished surface of which the graduation is marked in fine lines. One series of plugs carries the graduation in yards, and is intended to be standard at 62° Fahr.; and the other series carries meters, standard at 32° Fahr., or 0° Centigrade. The correction to the tape is read by a finely divided scale; sometimes with a low-power microscope, when the graduation on the tape is sufficiently fine to justify its use. The charge for testing a tape at Washington is $25. As to the standard temperature for bridge work, we assume that the U. S. standard is generally employed; but we would ask for a reply to this question from those more familiar with current practice in bridge shops. In the published transactions of the Ohio Society of Surveyors and Civil Engineers, for 1893 and 1894, will be found some very useful matter upon the subject of testing steel tapes, including valuable communications upon this subject from Prof. T. C. Mendenhall and the late J. E. Hilgard, each of whom have been at the head of the U. S. Coast and Geodetic Survey.—Ed.)

### The Link Movement Engine.

Sir: The description of Chapman's link movement engine, copied from "The Engineer" (London), in your issue of Aug. 13, p. 101, contains a surprising number of misstatements, considering its brevity.

Taking them in order; the pistons do not "move diagonally" but perpendicularly to each other. The crossheads and not the pistons "cross and recross midway at every stroke," and the crossheads and not the pistons are connected by a link, which, by the way, is not half the length of each piston but of their stroke. "A pin at each end of the link passing through the crossheads" does not "form the respective cranks." The statement that "circular motions cause the rotation of the shafts" is probably correct, though its connection with the reduction to a minimum of the pressure on the slippers is not very clear.

The "known geometrical fact" is correctly stated, but is perfectly irrelevant. It formed the basis of an old and now discarded parallel motion, but Mr. Chapman's engine does not utilize this principle in any way whatever. On the contrary, the principle of the "link movement" is that of the ordinary trammel for drawing ellipses. If the extremities of a straight line move in lines at right angles to each other then all points on the line will describe ellipses and the point at the center of the line will describe an ellipse of no eccentricity, or, in other words, a circle. Any of your "readers accustomed to geometrical work will see without further description" that this is not a parallel motion of any sort.

Fig. 1 does not "show the pistons (or either of them) at the ends of their strokes." They cannot both be at the ends of their strokes at the same time. It is true that "it is not possible to dispense with guides," but the Chicago nominations have as much to do with it as the reason which is given.

Finally, the link, now called a "flying crank," whatever that may be, cannot possibly "act like an ordinary drag link." The writer kindly says in conclusion that "this seems to be a very meritorious attempt to solve a difficult problem." Difficult attempt to solve a meritorious problem would be nearer the mark and more in keeping with some previous statements. The problem of driving a crank by two cylinders at right angles to each other is simple and common enough. It has been made difficult by the unusual method adopted for its solution, which seems much more ingenious than useful. A still more difficult problem would be to crowd a greater number of bulls and blunders into a mechanical description of equal length. In a somewhat extensive reading of engineering literature I have never seen anything approaching this except from "The Engineer." It is a gem in its way.

New York, Aug. 22, 1896. H. W. B.

### Mr. Donaldson's Proposed Standard Specification for Portland Cement.

Sir: In your issue of Sept. 10 I read the reply Mr. W. J. Donaldson makes to my criticism of his specification for Portland cement. In view of the series of errors he makes in quoting me and making me say directly the reverse from what your publication shows I did say in the clearest of English, I must trespass again on your valuable space for the purpose of correcting these errors.

I suggested no new specification, but gave to the engineering community, through your journal, a summary of what the leading engineers, chemists and scientists of the world had contributed to this subject, believing that in a matter such as the use of cement, which certainly is one wherein the questions of permanence and endurance enter, that the experience of years, and the concentrated wisdom of great men in the field, should carry weight and be of value to the profession.

In the conclusion of his argument for the adoption by the government of his new specification, Mr. Donaldson says:

> In conclusion we have only stated facts as they now exist and urged the adoption of one standard and that high in the specifications for quality, together with a uniform and specific method of testing which shall prove advantageous to the United States Government.

He says further in your issue of Sept. 10:

> It is a well-known fact that the recommendations of the Committee of the American Society of Civil Engineers are indefinite and altogether incapable of producing uniform results. The requirements are on the whole too low, and inadequate, which allow of second grade cements going into work where the highest grade Portland cements are intended.

Finally, in referring to the specifications cited by me on the subject of tensile strains, Mr. Donaldson says:

> The majority are old specifications whose requirements were favored some ten years ago when Portland cement, as an industry, was still in its infancy.

Now, from the above, it is certainly a fair criticism to say that Mr. Donaldson is "going it alone" in the matter of specifications. For a man, who proposes "one standard, and that a high one;" who objects to the American Society's specifications on account of "indefiniteness" and "inadequacy," and who finally has the hardihood to state that "ten years ago the Portland cement industry was still in its infancy," certainly lays himself open to comment on the boldness of his unsupported statements.

Will any engineer of standing, such as those who have constructed the monumental and colossal bridges, buildings, reservoirs, aqueducts and tunnels, railways and other public works done in the United States since June 21, 1885, the date of the American Society's specification, admit what Mr. Donaldson says of its requirements? Is it possible that all this work has been badly done with cement of "second grade," though done by such distinguished engineers as Fteley, Morrison, MacDonald, T. C. Clarke, Bogart, Herschel, Sayre, Becker, Wainwright, Burbank, John A. Wilson, Joseph M. Wilson, Eads, Stedman, Sooysmith, Craven, Nichols, Rodd, W. H. Brown, Douglas, Gowan, Bolier, Richards, as well as by hundreds of other well-known engineers? It cannot be the case, but it IS possible that Mr. Donaldson may be wrong in this, as well as in his statement as to the Portland cement industry, which he says "was still in its infancy" ten years ago, shortly before the time Mr. Donaldson appeared upon the scene as a cement dealer, though the works with which he is connected are only about four or five years old. As against Vicat, who wrote a book of 300 pages on the subject of limes and natural and artificial cements, published in London in 1837; C. W. Pasley, C. B., whose work was published in London in 1838; against the patents granted to Aspdin in 1824; Frost in 1822; against Reid, Faija and other early writers; against that long series of scientific papers on Portland cement, in the proceedings of the Institution of Civil Engineers, London; the American Society of Civil Engineers; the French Annales des Ponts et Chaussees; the German Cement Makers' Association Proceedings, beginning with John Grant's paper of 1865 and continued down to the present day, it is futile to talk as a scientific proposition of the Portland cement industry being in its infancy "ten years ago." As a commercial proposition it is equally preposterous, for the reports of the Bureau of Statistics of the Treasury show that in 1886 915,255 barrels of Portland cement were imported into the United States, while in 1887 and 1888 the figures were respectively 1,514,005 and 1,835,504 barrels, and the report of the German Cement Makers' Association for 1885 shows a production of 4,700,000 barrels, and Candlot, writing in Paris in 1891, puts the French product prior to 1880 at 700,000 barrels per annum, and the German production for 1888 at 6,000,000 barrels; the "Revue du Genie," Jan., Feb., 1888, puts the English product for 1887 at 7,500,000 barrels, and Rothwell in his book on the Mining Industry in the United States puts the American product of Portland cement for 1886 and 1887 at 150,000 and 250,000 barrels respectively. Infantile figures these!

So much for the "infancy of the Portland cement industry ten years ago." Mr. Donaldson's statement reminds one of the fly who, alighting on the wheel of a moving vehicle, remarked ecstatically, "See how I make it go." The industry was going when he came into it, the established specifications were in successful use then, and it would seem that to reverse established standards, not of one country, but of the civilized world, because of some "improvements made in grinding machinery and in modes of burning" only a few years in use is asking too much, especially as against the long time records of cement made under well-known methods.

From the above it will certainly appear that Mr. Donaldson is hardly the proper party to make a new specification, or even, as he now says, to "present the subject in the light of suggestion and thereby open up scientific discussion." Certainly if there were a doubt on this question, what follows will effectually remove it.

I criticised Mr. Donaldson's specification on four principal elements—chemical composition, fineness, checking and cracking, and tensile strength.

It must be admitted that if, in so serious a matter as the chemical composition of a cement, the proposer of a new specification fails, the bulk of what follows is of no use because the chemical composition would govern largely the other elements of the specification, and especially those relating to specific gravity, checking and cracking, and tensile strength. When, therefore, in reply to sixteen (16) authorities, viz., Candlot, Le Chatelier, Feret, de Rochemont, Tetmajer, Preussing, Redgrave, W. F. Reid, Henry Reid, Faija, Carey, Collins, DeSmedt, Spaulding, Jameson and Gilmore, giving analyses of nearly two hundred (200) brands of Portland cements of France, Belgium, Germany, England and America, Mr. Donaldson states that he "bases his requirements on the average results of the analyses of the best German, French and American brands, with a few Belgian and English cements," and fails to state the brands used in such analyses, the place of analysis, the time of analysis, and the chemist making such analyses, his case certainly fails, and he is right in stating and admitting what he does in reply to the writer and Professor Newberry, i. e., "The criticism on chemical composition appears to be well founded." So much therefore for this basic and most important branch of Mr. Donaldson's specification.

As to the question of fineness, I named 21 different specifications, embracing the official specifications of Belgium, Germany, Switzerland, France, Roumania, England, the United States, the recommendations of the American Society of Civil Engineers, and a number of other specifications in this country, against which Mr. Donaldson cites Henry Faija in his book on "Portland Cement for Users," dated 1890, who recommends fine grinding; but this same Henry Faija, whom I quoted under date of August 2, 1893 (three years later), recommends in his paper read before the World's Fair Congress, 8% on a 2,500 mesh sieve. On this branch of the case, certainly I am right when I say that Mr. Donaldson is arrayed against the world's scientific opinion.

Mr. Donaldson's specification on the subject of checking and cracking requires that a "cake of neat cement, after having set hard, is to be immersed in water at 212° F. and allowed to remain in the water at that temperature from 24 to 36 hours." This I interpret, and this I think can hardly be gainsaid, as a boiling test. In answering, I state: "The last report of the Committee of the German Cement Makers' Association, presented at the 1896 meeting on this subject, asks until 1898 to report, and meanwhile the normal cold water tests remain unassailed."

Germany: After three years' discussion, the boiling test was finally reported against at the session of 1893, by the German Cement Association, operating in conjunction with the Prussian Minister (Gary's paper, World's Fair Congress, Aug. 1893)."

French Government: Conference of engineers Ponts et Chaussees Cahier Guillan, Service de la Marine, Service de Colonie. None of these contain boiling tests. The French Government report is above referred to.

England: Faija's paper, World's Fair Congress, Aug. 2, 1893, Trans. Am. Soc. C. E., Oct. 1893; Trans. Am. Soc. C. E., Oct. 1893, recommends steaming tests only, and immersion at 116° and requires no boiling test, which he admits he has abandoned as unreliable, though first proposed by himself.

United States: U. S. Govt., District of Columbia specification, 1896, abandons boiling test. F. H. Lewis (Booth, Garret & Blair testing laboratory), Philadelphia, Proc. Am. Soc. C. E., Vol. XXXII., page 321, abandons boiling as "unreliable in indicating quality of cement." Am. Soc. C. E. specification recommends cold water and air tests only.

In reply to this Mr. Donaldson says: "Upon the question of hot test take up the first country, Germany. He (Mr. Lesley) admits that investigations are still being made on its reliability, and in the meantime the test is still made." Mr. Donaldson also cites what I quoted of Mr. Faija, and says "he immerses and steams in water at 116°, thereby showing that he must still have faith in the hot water test;" and finally Mr. Donaldson says, "from a brief summary of the above, it will be seen that the German, French and English authorities still adhere to the hot test, while the only two doubtful authorities are quoted for the United States."

Now the issue between Mr. Donaldson and myself is on the "boiling test," which he specifically recommends and nothing else, and a reading of what I wrote will show that the authorities I quoted are against that test absolutely and unequivocally.

As to the change in the District of Columbia specification, the authority for which Mr. Donaldson asks, I can only reply that the specification is signed, J. W. Ross, George Truesdell, Charles F. Powell, Commissioners, and of these, Mr. Powell is Engineer Commissioner. As this change was made after Mr. Donaldson's cement was rejected on the 1895 specifications requiring the boiling test, it would seem possible that he might have the latest information in that quarter.

As to the attempt to belittle the scientific reputation of Mr. F. H. Lewis, the well-known testing expert, I will say that if Mr. Donaldson had read Proc. Engineer's Club of Philadelphia, Vol. XI., No. 5, he would have found a second paper on cement by the writer mentioned, and if he had examined "Municipal Engineering" for August, 1896, he would also have discovered a controversial discussion between Mr. Lewis' firm and a Mr. W. J. Donaldson, in which Mr. Lewis' standing certainly did not suffer.

On the question of tensile strain, I cited the official specifications of France, Russia, Belgium, England, Germany and the Am. Soc. C. E. I also cited 21 specifications of leading engineers in this country, some requiring high and some low tensile strains, as mere indications of what leading authorities considered a specification should be. In reply to this, Mr. Donaldson, without citing a single authority, says broadly that "the majority are old specifications whose requirements were favored some 10 years ago, when Portland cement was an industry still in its infancy."

The specifications cited by me are all public and open to Mr. Donaldson's inspection, and it is only necessary to say that instead of "the majority being old ones" and "favored ten years ago," they are, with but possibly a single exception, in use at the present time or within at least two years, and by such engineers as Fteley, of the New York Aqueduct; Brown, of the Pennsylvania Railroad; Sayre, of the Lehigh Valley Railroad; Katte, of the New York Central Railroad; T. C. Clarke, of the Third Ave. Bridge; McNulty, of the Metropolitan Street Railway, New York; and a number of other equally distinguished engineers. Not a single specification is refuted by Mr. Donaldson, nor its accuracy questioned, nor a word of proof given as to the statement that the specifications are "old," but against this mass of testimony he states that "in the City of Philadelphia alone, five of the leading architects are using large quantities of Portland cement under specifications equally as high as those quoted by the writer," and still he fails to mention any single one of the architects in question, by name, or the work on which the cement is being used.

This sort of a reply is hardly sufficient to overthrow the mass of evidence I have adduced, and is on a par with his other statement as to the long time tests on the New York Aqueduct being on one brand of cement "exclusively." A glance at Mr. McCulloh's paper on the Sodom Dam ("Proc. Am. Soc. C. E.," April 5, 1893), would have shown him the absolute inaccuracy of such a statement, while an examination of the official records from which Mr. McCulloh's figures were taken, would have shown an enumeration of some 30 odd brands of Portland cement.

In conclusion, I am asked by Mr. Donaldson to state in what manner the "crude specifications" would prove harmful to "inexperienced engineers and architects." Having, I think, shown that the specification is crude and ill-digested, inasmuch as it is admittedly wrong chemically, and fails to find scientific support for its other members against the authorities cited by me, I can safely say that with the experience of the Aberdeen breakwater and the Saint Nazaire Bridge, in France, before us, that if any engineer were to use in salt water a cement containing 66% lime, and 2% sulphuric acid and 3½% magnesia, he would under Feret's experiments, as well as the papers describing the failures above mentioned, be in danger of having his work fail, especially as Mr. Donaldson does not in treating the question of sulphuric acid draw the proper distinction between salt and fresh water work.

Now engineers and architects, being professional men, stake their name, honor and reputation on every piece of work they do. Such a failure as I have mentioned would mean to an engineer or architect the loss of those things which are dearer than life itself. I think this makes it clear how a "crude" specification may do great harm.

Respectfully,

Robert W. Lesley, Assoc. Am. Soc. C. E.

22 South 15th St., Philadelphia, Pa., Sept. 21, 1896.

## Notes and Queries.

E. B., Montreal, P. Q., desires information as to the construction of continuous lime-kilns using coal as fuel, and desires the address of manufacturers or contractors who will undertake the construction of such kilns, or engineers who will furnish designs for them.

THE LARGEST BUILDING EVER MOVED IN THIS country was a freight warehouse of the B. & O. R. R. in Baltimore, which was moved Sept. 8 to 12. The building is 440 ft. long, 120 ft. wide and 60 ft. high. It is a wood and iron structure and was moved to make room for a new dock. The work consumed 5½ days. The building contained a great quantity of freight, among which was 3,000 cases of china and crockery, but not a dish was cracked in the moving. The men were engaged five weeks making preparations for the move. On top of the old and the new foundations were placed the sills or tracks upon which the building was to run. These tracks numbered 40, each consisting of two 6 × 12-in. timbers. On top of these were placed the 1,000 rollers, each a piece of 5-in. pipe 3 ft. in length. There were 25 rollers to each of the 40 tracks. Between the top of the rollers and the floor beams of the building were arranged more of the 6 × 12-in. timbers. In all 6,600 of the 6 × 12-in. timbers were used, each about 30 ft. long. The 255 wooden pallars which supported the warehouse were then sawed away and the structure rested upon the rollers. Along one side of the building were placed 40 5-ton screw jacks. They were braced against a railroad track, an adjoining warehouse and the tracks upon which the rollers ran. Two men stood at each jack. At a given signal the men responded with military precision, and each jack was given a quarter of a turn, moving the great building a fraction of an inch. Afterward the progress averaged 2 ft. an hour for 5½ days. The structure arrived at its new foundation without a strained timber or a bolt. The jacks were again used in raising the warehouse enough to allow the removal of the jacks, after which it was lowered to the new foundations. The structure cost $35,000 ten years ago, and it cost $15,000 to make the removal.

AN IMPROVED HOWELL AUTOMOBILE TORPEDO has been lately tested by the U. S. Government and the results are highly satisfactory. The new torpedo is 14½ ft. long, 17 ins. in greatest diameter, has a launching weight of 1,130 lbs., with a reserve buoyancy of 20 lbs., and an immersed displacement in sea water of 1,150 lbs. It carries a charge of 174 lbs. of gun cotton. The mean speed over a range of 400 yds. is 33 knots; over a 600-yd. range, 30 knots, and over 800 yds., 28.5 knots. The extreme effective range for regular service is 1,000 yds. The older Howell torpedo was 11 ft. 2 ins. long, and 14 ins. in diameter, and had an effective range of 600 yds., with a speed of 18 knots. It carried only 82.75 lbs. of gun cotton. Instead of being propelled by compressed air stored in the torpedo itself, as in other types, the Howell torpedo has a turbine motor attached to the launching tube, which gives an exceedingly high speed to a heavy steel fly-wheel within the tube; the stored-up energy of this fly-wheel is then transmitted to two propellers by gearing. The torpedo is launched by indirect gun powder impulse, with the fly-wheel revolving at a speed of about 10,000 revolutions per minute. Out of 346 shots, with the launching tube 2½ ft. above the water, there were 332 hits, 10 misses, and 4 accidents; with the tube 9½ ft. above the water there were 63 hits out of 69 shots. The target was a rectangle 21 yds. long by 1 yd. wide, 8 ft. below the water surface.

THE ARMORED CRUISER "BROOKLYN" is officially declared to have made 21.9117 knots per hour as the average of her late trial run, and the Navy Department awards the builders, the Cramps, of Philadelphia, a premium of $350,000. The contract speed was 20 knots. The Inspection Board also says that the weights are in accordance with the contract, the machinery performance was satisfactory and her steering qualities in smooth water were excellent. Owing to the absence of heavy weather during her trial trip the behavior of the ship as respects rolling and pitching was not tested.

A NEW TRANSATLANTIC STEAMSHIP LINE, formed by the consolidation of the line of the Wilson Bros., at Hull, England, and the Leyland-Furness line, of London, is announced to run a weekly service between Brooklyn and London, and also between Boston and London. Contracts for five new vessels have been given out, to be ready for service next June. They will have a cargo capacity of 8,000 tons, and accommodations for 80 saloon passengers. The speed will be 14 knots per hour.

AN ARMOR-PIERCING PROJECTILE designed by Isaac G. Johnson & Co., of Spuyten Duyvil, has again been successfully tested at Indian Head upon a 10-in. rerolled Harveyized steel plate made by Carnegie & Co. for the Russian government. A 6-in. projectile of solid steel was used, hardened by a special process and capped by soft steel. The projectile weighed 100 lbs., including the 5-lb. cap, and smokeless powder was employed to impart an initial velocity of 2,540 ft. sec. The projectile went clear through the 10-in. plate, through 12 ins. of oak and three steel plates, 7-16-in. thick each, and 8 ft. into the dirt back of the target. The cap alone was seriously injured, the shot being almost intact when dug out of the earth.

THE DES MOINES, IA., WATER-WORKS are likely to be purchased by the city from the private company which owns them. The city has offered $800,000 for the works. Litigation between the city and the company has been in progress for some time.

WEATHER TABLE FOR AUGUST, 1896. (Furnished to Engineering News by the Department of Agriculture.)

| | Stations. | Temperature. (Degrees Fahrenheit.) | | | | Wind. | | | Precipitation—rain or melted snow—inches. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Velocity in miles per hour. | | Direction at time of max. velocity. | | | |
| | | Average. | Max. | Min. | Range. | Average. | Max. | | Total. | Heaviest in 24 hours. | No. of rainy days. |
| Northern Cities. | Northfield, Vt. | 64.0 | 90 | 37 | 53 | 7.0 | 27 | NW | 2.27 | .51 | 12 |
| | Portland, Me. | 66.1 | 90 | 49 | 41 | 5.7 | 24 | S | 2.87 | .82 | 18 |
| | New York City | 73.0 | 94 | 56 | 38 | 10.1 | 50 | NW | 2.46 | .74 | 10 |
| | Pittsburg, Pa. | 72.6 | 94 | 50 | 44 | 4.6 | 20 | N | 4.09 | 2.31 | 12 |
| | Chicago, Ill. | 72.8 | 98 | 54 | 44 | 14.1 | 36 | NW | 3.52 | 1.24 | 6 |
| | Omaha, Neb. | 73.9 | 96 | 54 | 42 | 7.6 | 54 | NE | 3.50 | 1.71 | 11 |
| | St. Paul, Minn. | 70.0 | 100 | 45 | 55 | 6 5 | 60 | NW | 4 48 | 1.68 | 10 |
| | Duluth, Minn. | 65.4 | 90 | 46 | 44 | 9.2 | 33 | SW | 2.41 | .93 | 9 |
| | Bismarck, N. Dak. | 67.2 | 98 | 40 | 58 | 8.9 | 36 | NW | 1.77 | .85 | 10 |
| | Average. | 69.6 | 94 | 48 | 47 | 8.2 | 38 | | 3.01 | 1.20 | 11 |
| Southern Cities. | Washington, D. C. | 75.8 | 98 | 50 | 48 | 5.0 | 24 | N | 2.65 | 1.91 | 7 |
| | Louisville, Ky. | 77.7 | 98 | 55 | 43 | 6.1 | 37 | NW | 4.51 | 2.00 | 7 |
| | St Louis, Mo. | 79.4 | 100 | 60 | 40 | 8.9 | 45 | W | 2.12 | 1.36 | 7 |
| | Savannah, Ga. | 81.8 | 98 | 61 | 37 | 6.4 | 32 | NW | 5.78 | 2.72 | 11 |
| | Kansas City, Mo. | 77.4 | 103 | 58 | 45 | 4.6 | 29 | SE | 3.33 | 1.80 | 6 |
| | Jacksonville, Fla. | 82.8 | 96 | 64 | 32 | 6.5 | 26 | W | 6.16 | 2.38 | 10 |
| | Chattanooga, Tenn. | 80 4 | 97 | 63 | 34 | 5.1 | 25 | NW | 1.90 | 1.61 | 7 |
| | New Orleans, La. | 83.0 | 96 | 70 | 26 | 6.3 | 28 | NE | 5.31 | .90 | 12 |
| | Memphis, Tenn. | 82.3 | 101 | 60 | 41 | 7.5 | 42 | W | 0.84 | .25 | 9 |
| | Palestine, Tex. | 84.3 | 102 | 60 | 42 | 5.7 | 23 | NW | 1.19 | .58 | 5 |
| | Average. | 80.5 | 99 | 60 | 39 | 6.2 | 31 | | 3.18 | 1.55 | 8 |
| Western Cities. | Helena, Mont. | 65.2 | 92 | 42 | 50 | 7.0 | 45 | SW | 0.86 | .32 | 8 |
| | Port Angeles, Wash. | 58.2 | 77 | 45 | 32 | 5.2 | 20 | W | 0.47 | .36 | 6 |
| | San Francisco, Cal. | 59.5 | 72 | 52 | 20 | 13.9 | 36 | W | 0.09 | .06 | 3 |
| | Salt Lake City, Utah. | 73 7 | 96 | 55 | 41 | 5.6 | 26 | SE | 1.47 | .65 | 8 |
| | Santa Fe, N. Mex. | 68 0 | 88 | 49 | 39 | 6.2 | 32 | NE | 1.47 | .44 | 14 |
| | Denver, Colo. | 71.8 | 94 | 43 | 51 | 6.8 | 39 | SW | 0.97 | .65 | 7 |
| | Yuma, Ariz. | 90.0 | 113 | 71 | 42 | 6 4 | 40 | SW | 0.32 | .12 | 7 |
| | Average. | 69.5 | 90 | 51 | 39 | 7.3 | 34 | | 0.81 | .37 | 8 |

## COMPRESSED-AIR PLANT ON THE CONSTRUCTION OF THE JEROME PARK RESERVOIR.

The use of compressed air for power purposes and power transmission has had a very great and comprehensive growth within the past few years, and one of the most recent and interesting applications of this power is on the extensive contract work for the construction of the Jerome Park reservoir, for the water supply system of New York city. As the contract amounts to nearly $5,500,000, and will extend over about seven years, there was ample reason for carefully considering the comparative advantages and economy of different methods of supplying power for the drills, hoists, pumps, etc., to be used on the work, and as a result of this investigation it was decided to use compressed air, distributed to all parts of the work by pipe lines from a central power plant. This plant is operated by one engineman and one fireman. The main pipe lines will remain practically permanent during the work, the branches being shifted, and extended as required by the progress made in excavation. This system will undoubtedly effect a considerable saving in fuel and labor expenses as compared with the more common methods.

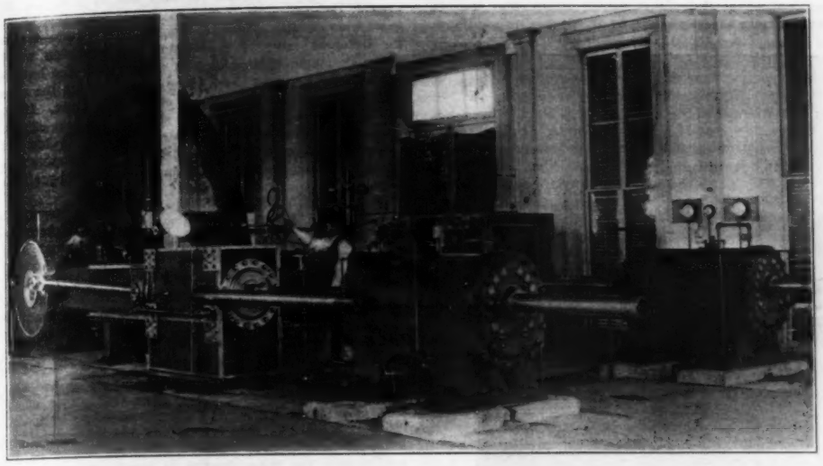


FIG. 1.—AIR COMPRESSING PLANT FOR THE WORK ON THE JEROME PARK RESERVOIR.

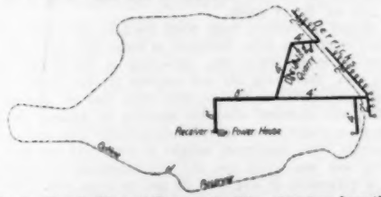



Fig. 2.—Sketch Plan of Reservoir Site, showing Location of Power House, Transmission Pipes and Working Plant.

On such construction work the general practice is to use steam power, with separate boilers for each one or two hoists, and other boilers near groups of drills. This practice is necessarily wasteful in fuel, as the amount of fuel used is excessive, the boilers not being adapted for or worked with a view to economical consumption, and much fuel being burned without doing any work during dinner hours and when the machines are stopped for any cause, while leaky joints and condensation in the long lines of pipes always cause considerable waste and trouble. Besides this a separate attendant is required for every boiler.

The Jerome Park reservoir, where this compressed air plant has been installed, was described in our issue of July 18, 1895. It is situated near Van Cortlandt Park, on the New York & Putnam Division of the New York Central R. R., about 11 miles from the Grand Central Station on 42d St., and 5 miles north of the Harlem River. It will cover about 300 acres of land and will have a capacity of 2,000,000,000 gallons. The construction will require about 4,000,000 cu. yds. of earth excavation, 3,200,000 cu. yds. of rock excavation, 150,000 cu. yds. of concrete masonry, 82,000 cu. yds. of brick masonry, 113,000 cu. yds. of rubble masonry and 250,000 sq. yds. of rubble masonry facework. The masonry includes heavy core walls for the embankments. The bids for the work ranged from about $5,000,000 to $13,000,000, and the contract was awarded in August, 1895, to Mr. John B. McDonald, of Baltimore, Md., and New York city, at $5,473,000. Preparations for commencing the work were at once started, and the work is now in active progress. At the present time about 550 men are at work, while the plant includes 8 narrow gage contractors' steam locomotives, 2 steam shovels, 18 derrick hoists, 10 drills and a number of wagons, teams, dump cars, etc. Besides this, offices, living quarters, stables and stores of all kinds of material and supplies have been established, as the work will last for about seven years, the date set for the completion of the contract being Nov. 1, 1902.

The contract for the air compressing plant was placed by Mr. McDonald with the Ingersoll-Sergeant Drill Co., of New York city, and this has now been installed and put in operation, having been started on May 14. For a power house, one of the large buildings of the club at the old Jerome Park racecourse is used; the building having been removed bodily to a convenient situation. In this are installed a cross-compound Corliss engine of 600-HP., with a compressing cylinder behind each of the steam cylinders. The engine drives a flywheel 25 ft. diameter, weighing 50,000 lbs., mounted on a shaft 14 ins. diameter, the shaft having an eccentric keyed on each side of the wheel and being driven by means of a crank disk at each end. The main shaft bearings are 14 × 26 ins. The steam cylinders are 24 × 48 ins. and 44 × 48 ins.; while the air cylinders are 24¼ × 48 ins. The cylinders are 6 ft. apart, longitudinally, and 14 ft. c. to c. transversely. The walls of the air cylinders are cooled by water jackets. The compressor is of the company's standard design, which is probably familiar to most of our readers. The air enters the cylinder through a hollow tail-rod, and the piston has an annular disk valve in each face, the space between the open valve and its seat being about ¼-in. On the forward stroke the front inlet valve is closed and the air in front of the piston is forced through the front discharge valves as soon as the cylinder pressure exceeds the receiver pressure, while at the same time air is passing through the tail-rod and open rear valve into the space behind the piston. On the return stroke the rear inlet valve is closed and the air is forced through the rear discharge valves, while the air entering through the tail-rod passes through the open inlet valve in the front face of the piston and fills the forward end of the cylinder. This arrangement was shown and described in detail in our issue of Sept. 27, 1890. Each air cylinder is also fitted with a regulator or loaded relief valve by which the load is thrown off when the normal receiver pressure is exceeded owing to the air not being used. The normal pressure in this case is 75 lbs., and when it rises to 80 lbs. a passage is opened connecting both ends of the cylinder, so that the piston has an equal air pressure on both sides, both inlet valves being thus kept closed and the piston moving to and fro without doing any work. When the air pressure has fallen a trifle below 80 lbs. the regulator closes, and compression is then resumed. This device was fully illustrated and described in our issue of March 28, 1891. The cut-off of the steam cylinders is regulated automatically by the load, as in all Corliss engines. From the compressor cylinders the air passes to the receiver, which is a riveted steel cylinder or tank 5 ft. 6 ins. diameter and 18 ft. long, placed just outside the engine house.

FIG. 3.—GROUP OF DERRICKS OPERATED BY COMPRESSED AIR.

The engine is intended to work as a condensing engine, but is not being so worked at present, and the connecting rod to the rocking lever of the condenser pump is disconnected. The reason for this is that there is not now a supply of water available for condensing purposes, but, of course, the engine cannot meanwhile work so economically in fuel consumption. The water for the boiler is taken from a well sunk near the engine house and

a reservoir for the condensing water has been built. Steam is supplied by a single water-tube boiler made by the Hogan Boiler Co., of Middletown, N. Y., the boiler having three furnaces. The boiler is rated at 250 HP., and carries a pressure of 120 lbs. The entire power plant is handled by one engineman and one fireman. The engine and compressor were built at the works of the Ingersoll-Sergeant Drill Co., at Easton, Pa. This

FIG. 4.—EXCAVATION AND LOADING OF ROCK BY COMPRESSED AIR PLANT.

plant, shown in Fig 1, was started up on May 14, and later on, when a larger force is at work on the reservoir, it is intended to put in a duplicate plant, working the air cylinders compound.

Fig. 2 is a plan of the work, with an outline of the boundaries of the reservoir, and showing the positions of the pipe line, drills, hoists, etc., as at present existing. From the receiver an 8-in. pipe extends for a distance of 1,500 ft., and is followed by two main lines of 4-in. pipe, from which again run 2-in. pipes aggregating about 2,000 ft. in length. The branch pipes to the machines are 1½ ins. diameter, this being the smallest size used. The aggregate length of the piping system is now about 6,300 ft. Another 8-in. main is intended to be laid later, in a direction opposite to that taken by the present 8-in. main. All the pipe has screwed joints. There is one reheater on the 4-in. pipe line, this being of the Sergeant pattern, described in our issue of May 9, 1895. The heater is a truncated cone 3 ft. 6 in. in diameter at the base and 4 ft. 6 ins. high, the center of which forms a stove; the air enters at the top and passes down over the heating surface, the volume of air space increasing as the air expands, so that the velocity and friction remain practically constant. The use of this reheater is said to increase the efficiency 33% over work done by the same volume of air used cold. The air pressure is designed to be 75 lbs. per sq. in. at the compressor and 70 lbs. at the tools.

There are now in use 10 drills, 18 derrick hoists and 2 pumps. The drills are of the well-known Ingersoll-Sergeant make. The hoisting engines are of the Lidgerwood make, with two cylinders 7×10 ins. and double drums. In the building of the masonry core walls for the embankments a row of derricks is erected, each derrick being operated by a hoisting engine, but the booms are swung by hand by means of guy ropes. The masts and booms are sticks 14×14 ins., the masts being 65 ft. long, and the booms are 62 ft. long. The derricks have a lift of 57 ft., a working radius of 118 ft., and a hoisting capacity of 10 tons. The pumps are small horizontal pumps placed in the trenches for the core wall foundations.

Figs. 3 and 4 show two views of the work now in progress. The derricks are all operated by compressed air, and the rock excavation shown was effected by groups of drills operated by air. For photographs and other information used in this article we are indebted to the Ingersoll-Sergeant Drill Co., and to Mr. Henry B. Reed, C. E., who is superintendent for Mr. McDonald, the contractor.

## THE EFFECT OF HIGH RATES OF COMBUSTION UPON THE EFFICIENCY OF LOCOMOTIVE BOILERS.*

By Prof. W. F. M. Goss.**

The experiments with which this paper is concerned were carried out a few months ago in the locomotive laboratory of Purdue University.

The boiler of any given locomotive is most efficient when worked at the lowest power practicable; that is, when the rate of combustion in its firebox is minimum. For the development of a higher power, the rate of combustion must be increased, and, as a result, the efficiency of the boiler is lowered.

The relation between the rate of combustion and the weight of water per pound of coal for the Purdue locomotive, "Schenectady," while using Brazil block coal, is shown by Fig. 1. From this diagram it appears that when coal is burned at the rate of 50 lbs. per sq. ft. of grate per hour, 8 lbs. of water are evaporated for each pound of coal; while if the rate of combustion is increased to 180 lbs. per sq. ft. of grate, the evaporation falls to about 5 lbs.—a loss in water evaporated per pound of coal of nearly 40%. This loss may be due to a failure of the heating surfaces to absorb properly the increased volume of heat passing over them, or to the imperfect combustion of the fuel upon the grate, or it may be due to a combination of these causes.

That a portion of the loss occurs along the heating surfaces hardly admits of question, since it is well known that any increase in the rate of combustion results in a rise in the temperature of the smokebox gases; but whether, under ordinary conditions, any considerable portion of the loss shown by Fig. 1 is due to imperfect combustion, has not been demonstrated, and it is this question especially that the present paper attempts to treat.

The importance of the subject is emphasized by the varying practice of locomotive designers, who, in some cases, have so designed large boilers as to allow a large grate; while in others they have been content to use a grate of moderate size, upon which they have forced the combustion beyond limits which had hitherto been customary.

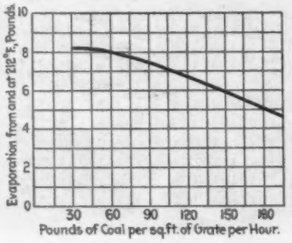



Fig. 1.—Relation between Rate of Combustion and Weight of Water Evaporated per Pound of Coal in Locomotive "Schenectady."

A separation of the losses which may occur at the grate from those which take place along the heating surface cannot be accomplished by boiler tests alone, because the results of such tests give the combined effect of both these losses. There are two variables involved, and in order that either may be determined one must be given a constant value. In the tests described, action along the heating surface was maintained constant, while conditions at the grate were varied.

As a preliminary step, a number of tests were outlined in which the total weight of fuel fired was to be constant throughout the series, while the rate of combustion was to be made different for each test by changing the area of the grate. It is evident that if the action at the grate were equally efficient during the several tests—that is, for different rates of combustion—this provision would cause the same volume of heat to pass over the heating surfaces of the boiler, and hence would produce the same evaporation and the same smokebox temperature. If, on the other hand, the combustion should prove less efficient for any one test than for others, a smaller volume of heat would sweep the heating surface, less water would be evaporated, and the smokebox temperature would probably be lower.

The outline provided for all observations usual in boiler testing, and, in addition to these, for a determination of the weight of fuel lost in the form of sparks, and for chemical analyses of the fuel used, of the sparks caught and of the smokebox gases.

The first test was run with the locomotive under normal conditions. The whole grate was covered with fuel, the throttle was fully open, the cut-off approximately 6 ins. and the load such as to make the speed 25 miles per hour. These conditions gave a rate of combustion of 61 lbs. of coal per sq. ft. of grate per hour.

In preparation for the second test, one-quarter of the grate was made non-effective, or "deadened" by a covering of fire-brick. The exhaust tip was reduced, so that while the engine was running as before and using approximately the same amount of steam, the same total weight of fuel could be burned on the reduced grate as in the first test had been burned on the whole grate. Trial tests were run until it was known that the changes made would permit the desired conditions to be maintained. The rate of combustion in this test was 84 lbs. per sq. ft. of grate.

In preparation for the third test, the grate surface was reduced to half its original area, and the rate of combustion was increased to 124 lbs. per sq. ft. of grate; and during the fourth test only one-quarter of the original grate was used, the combustion in this case rising to 241 lbs. per sq. ft. of grate.

It should be evident from what precedes, that the prescribed conditions were designed to make each test a duplicate of every other test, excepting in the matter of grate area, this being the one variable for the series.

The coal used in the several tests was of uniform quality, the chemical analyses showing no greater variation than might occur in different samples from a single shipment. The maximum weight of coal fired per hour in any test was 1,087 lbs. and the minimum was 1,038 lbs., a difference of less than 50 lbs. in more than 1,000, while the variation during three of the four tests does not exceed 1.2% of the weight fired. All external conditions affecting the action of the boiler were uniform throughout the series.

The one variable for the series—namely, a different rate of combustion—was secured by keeping constant the weight of coal fired and by varying the area of the grate. There were burned each hour on each square foot of effective grate surface, 61 lbs. during the first test, 84 during the second, 124 during the third, and 241 during the fourth. These values more than cover the entire range of rates usual in locomotives.

Evidence of losses at the grate with increased rates of combustion is to be found in the record of water evaporated per pound of coal, which, for the several tests, is as follows:

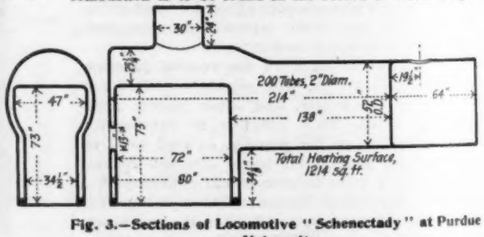



Fig. 3.—Sections of Locomotive "Schenectady" at Purdue University.

| Number of test | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Rate of combustion; lbs. of coal per sq. ft. of grate surface | 61 | 84 | 124 | 241 |
| Equivalent evaporation from and at 212° F.; lbs. of water per lb. of coal | 8.26 | 7.87 | 7.52 | 6.67 |
| Loss of evaporation in terms of the evaporation for Test No. 1, per cent | | 4.7 | 9.0 | 19.2 |

In consideration of all the conditions governing the experiments, it would seem fair to assume that the decrease of 19% in the weight of water evaporated, a result which comes from increasing the rate of combustion from 61 to 241, is a loss which occurs wholly at the grate.

A large fraction of this loss is to be accounted for

*Abstract of a paper presented at the meeting of the New York Railroad Club, Sept. 17, 1896.

**Professor of Mechanical Engineering, Purdue University, Lafayette, Ind.

by the escape of sparks, and it is significant that, as the sparks increase in volume, their heating value also increases.

By reducing the weight of sparks to an equivalent weight of coal, on the basis of their relative heating value, it is possible to make the following comparison:

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Number of test | | | | |
| Rate of combustion | 61 | 84 | 124 | 241 |
| Total lbs. of coal per hour | 1,074 | 1,078 | 1,086 | 1,038 |
| Total lbs. of sparks per hour | 61.5 | 95.1 | 128.6 | 176.3 |
| Lbs. of coal equivalent to spark losses per hour | 46 | 77 | 111 | 161 |
| Value of spark losses in per cent. of coal fired | 4.3 | 7.2 | 10.2 | 15.5 |

According to popular judgment, the loss of heat by sparks has always appeared small; while the data show

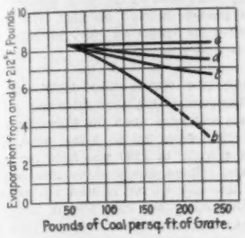



Fig. 2.—Relation Between Rate of Combustion and Losses of Heat by Different Causes in Locomotive Boilers.

that, under conditions which are now common, it may represent more than 10% of the fuel value of coal fired. It is evident, however, that these losses will in general depend very much upon the quality of coal, and it should be noted that the Brazil block which was used in the tests under consideration is quite friable.

Without attempting a full discussion of the analyses of the smokebox gases, attention may be directed to two important facts. These are, first, the large percentage of oxygen shown, indicating a supply of air greatly in excess of that required for combustion; and secondly, the absence of carbon-monoxide (C O) in all excepting the last test.

All air admitted to the furnace in excess of that required for combustion is heated from the temperature of the atmosphere to that of the smokebox, and by this process heat is taken from the furnace. As the data show an increasing amount of air during the third and fourth tests of the series, it would appear that this cause must have operated to reduce the performance of the boiler as the rate of combustion was increased.

The presence of carbon-monoxide (C O) in the smokebox gases is accepted as proof of imperfect combustion. This gas, as already noted, occurs only in Test No. 4. It has long been supposed that its formation is due to thick firing, and its failure to burn after it is formed, to defi-

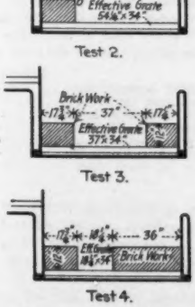



Fig. 4.—Grate Surface of Locomotive "Schenectady" as Reduced.

cient air supply, or to a temperature too low to ignite it. Upon this theory, its presence in Test No. 4, and its absence in the other three, are difficult to explain.

In contradiction of the old theory, however, Herr R. Ernst* has recently shown that the amount of this gas (C O) formed in the combustion of carbon depends upon the temperature of the fire; that, as the temperature of the fire is increased, a larger proportion of the carbon is converted into C O until under very high rates of combustion, or, more specifically, when the temperature of the fire is above 1,800° F., the first process of combustion is the entire conversion of the carbon into this gas. He has also shown that this gas will not burn, even in the presence of air, so long as its temperature is above 1,800° F.; it must be cooled before it will burn. But, theory aside, the facts remain that the tests show very small losses by imperfect combustion, even when the rate of combustion is highest.

*"The Principles of Combustion," a paper by R. Ernst, published as an inaugural dissertation at the University of Giessen, Hamburg, 1892. (See "The Engineer," London, Aug. 4, 1893.)

## Conclusions.

The results show that the most efficient furnace action accompanies the lowest rates of combustion; and while the precise relationships established by the experiments may not hold for fuel which is different from that employed, nevertheless they enforce the general conclusion that very high rates of combustion are not desirable, and, consequently, that the grate of a locomotive should be made so large that exceptionally high rates will not be necessary. They emphasize, also, the importance of spark losses, which, during the experiments under discussion, practically equalled in value all other losses occurring at the grate.

Leaving the conditions peculiar to the experiments, and assuming that the results obtained from them may be applied to the locomotive "Schenectady," when working under normal conditions, we find that the losses in evaporative efficiency which occur when the rate of combustion is increased above 50 lbs., may be accounted for approximately as follows: The relation between the rate of combustion and the water evaporated per pound of coal, under normal conditions, is represented by the line a b, Fig. 2. If it could be assumed that the heat developed in the furnace would be absorbed with the same degree of completeness for all rates of combustion, the evaporation would rise to the line a c; if, in addition to this, it could also be assumed that there were no spark losses, the evaporation would rise to the line a d; finally, if, in addition to these, it could be assumed that there were no losses by the excessive admission of air, or by incomplete combustion, then the evaporation would remain constant for all rates of combustion, and would be represented by the line a e.

That is, with the boiler under normal conditions, the area a b c represents the loss occasioned by deficient heating surface, the area a c d that occasioned by spark losses, and the area a d e that occasioned by excessive amounts of air and by imperfect combustion.

## Apparatus and Methods.

The apparatus employed constitutes a portion of the permanent equipment of the locomotive laboratory of Purdue University. The locomotive is of the eight-wheeled type, with 17 × 24-in. cylinders, and weighs 85,000 lbs. The boiler, with which the present work especially concerns itself, is shown in outline by Fig. 3.

The deadening, which was employed to cut out portions of the grate, was of brick laid up in fire-clay, the effect being to make the covered portions of the grate as nearly air-tight as possible. The material extended across the breadth of the firebox, the sections of the grate covered being disconnected from the rocking mechanism, so that the remainder could be used with undiminished effect. Its distribution during the several tests is shown by Fig. 4.

Early in the second test, ash piled up on the deadening, as indicated by the line a b, Fig. 4; but as the accumulation did not reach the lower tubes it was not dislodged. During the third test there was less of this deposit, and during the fourth still less, an effect probably due to the presence of a stronger draft.

The thickness of fire for each test was not greater than was necessary to the easy maintenance of the steam pressure. The firing was always at regular intervals, and usually only three shovelfuls were thrown in at one time. In the fourth test the thickness of the fire equaled that of the deadening.

The samples of smokebox gases for analyses were drawn from a point near the center of the smokebox. Ten minutes were occupied in obtaining the sample, a period sufficiently long to cover all conditions of fire.

The smokebox temperatures were obtained by means of a Le Chatelier electric pyrometer.

The weight of sparks or cinders passing the heating surfaces is the sum of those caught in the front end of the locomotive and those passing out at the top of the stack. The sparks which accumulated in the front end were easily collected and weighed. Of those which passed out of the stack, a portion only were collected, the sample being so chosen as to serve as a basis from which the value of the whole could be estimated. The apparatus employed in this latter process is shown by Fig. 5. It consists of an inverted U-tube of galvanized iron, securely fastened to a movable frame, by means of which the tip, which constitutes one extremity of the tube, can be projected across the top of the locomotive smokestack. The outer end of the tube may thus be made completely to intercept a portion of the stream issuing from the stack, and the continuous action of this stream is sufficient to drive the intercepted portion through the tube and out at the other end. The gases passing the tube bear the sparks on their current, and they are collected in a bucket set to entrap them. Reference marks upon the sliding and the fixed frames permit the tubes to be placed in definite locations relative to the center of the stack. This device, when in service, catches everything excepting the lightest soot, which is allowed to escape unaccounted for.

After assuming the cross-section of the stream issuing from the stack to be cut up, by a series of concentric circles, into one circular and several annular areas, as shown by Fig. 6, the small end of the U-tube was placed in the position marked I and held there for thirty minutes, the sparks collected during this interval being credited to this position. The tube was then moved to the position II, where it remained for another period of thirty minutes. In like manner, it was made to occupy, successively, the positions III and IV, and also the positions $I_1$, $II_1$, $III_1$ and $IV_1$, the weight of sparks caught during each interval being credited to the corresponding position occupied by the small end of the tube. This end of the tube had an area of 1 sq. in., and it was assumed that the average weight of sparks passing the tube while in the positions I and $I_1$ would be the same as that passing every square inch in the annular space in which these positions are located.

The engines of the locomotive were not involved in the tests, excepting as they served to shake the boiler, to furnish draft and to consume the steam generated. While

Observed and Calculated Data.

| Test number | 1. | 2. | 3. | 4. |
|---|---|---|---|---|
| Month and day (1896) | Feb. 8. | Feb. 11. | Feb. 15. | Feb. 22. |
| Duration of test, hours | 6. | 6. | 6. | 6. |
| Approximate portion of whole grate used | Full. | ¾ | ½ | ¼ |
| Exact area of effective grate, sq. ft. | 17.50 | 13.01 | 8.74 | 4.31 |
| Analysis of Coal.—Fixed carbon, % | 49.65 | 51.84 | 51.09 | 51.59 |
| Volatile matter, % | 40.29 | 39.00 | 38.93 | 38.87 |
| Combined moisture, % | 3.15 | 3.62 | 2.35 | 3.44 |
| Ash, % | 6.91 | 5.54 | 7.63 | 6.10 |
| Coal (Brazil block)—Fired, lbs. | 6,522.00 | 6,628.00 | 6,716.00 | 6,328.00 |
| Dry coal for test, lbs. | 6,443.00 | 6,522.00 | 6,514.00 | 6,227.00 |
| Dry coal per hour, lbs. | 1,074.00 | 1,087.00 | 1,086.00 | 1,038.00 |
| Dry coal per hour per sq. ft. of grate, lbs. | 61.40 | 83.50 | 124.20 | 240.80 |
| Fixed carbon in coal, dry and free from ash, % | 56.00 | 57.00 | 57.00 | 57.00 |
| Approximate B. T. U. per lbs. of combustible | 13,800.00 | 14,040.00 | 14,040.00 | 14,040.00 |
| Approximate B. T. U. per lbs of dry coal | 13,000.00 | 13,000.00 | 13,000.00 | 13,000.00 |
| Theoretical evap. from and at 212° per lb. of dry coal | 13.46 | 13.46 | 13.46 | 13.46 |
| Ash.—Dry ash in ash-pan, lbs. | 446.00 | 396.00 | 297.00 | 164.00 |
| Ash in coal fired as shown by analysis of coal, lbs. | 445.00 | 361.00 | 497.00 | 380.00 |
| Ash by analysis, minus lbs. found in ash-pan, lbs. | −1.00 | −35.00 | 200.00 | 216.00 |
| Analysis of sparks.—Fixed carbon, % | 61.74 | 64.88 | 71.32 | 76.44 |
| Volatile matter, % | 4.36 | 4.16 | 3.45 | 3.29 |
| Combined moisture, % | 1.82 | 1.82 | 1.66 | 1.86 |
| Ash, % | 32.08 | 29.14 | 23.57 | 18.41 |
| Sparks.—Caught in front-end during test, lbs. | 75.00 | 213.00 | 494.00 | 566.00 |
| Passing out of stack for test, lbs | 294.00 | 358.00 | 278.00 | 492.00 |
| Total lbs. of sparks for test | 369.00 | 571.00 | 772.00 | 1,058.00 |
| Sparks per sq. ft. of grate per hour, lbs. | 3.50 | 7.30 | 14.70 | 41.00 |
| Approximate B. T. U. per lbs. of sparks | 9,870.00 | 10,360.00 | 11,200.00 | 11,880.00 |
| Coal equivalent in heating value to 1 lb. of sparks | .75 | .80 | .86 | .91 |
| Coal equiv. in heat'g value to total weight of sparks, lbs. | 277.00 | 457.00 | 664.00 | 963.00 |
| Analysis of Smokebox Gases.—Carbon dioxide, % | 5.25 | 6.25 | 4.80 | 1.80 |
| Heavy hydro-carbons, % | .50 | .40 | .40 | .50 |
| Oxygen, % | 12.15 | 11.80 | 14.60 | 18.70 |
| Carbon monoxide, % | ... | ... | ... | .55 |
| Nitrogen, % | 81.90 | 81.55 | 80.20 | 78.45 |
| Other Smokebox Data.—Diameter of double exhaust tip | 3.00 | 2.75 | 2.35 | 1.75 |
| Draft in ins. of water | 2.20 | 2.50 | 3.30 | 5.60 |
| Temperature of smokebox, deg. F. | 647.00 | 629.00 | 610.00 | 500.00 |
| Water and Steam.—Water delivered to boiler, lbs. | 44,756.00 | 43,081.00 | 40,710.00 | 43,770.00 |
| Temperature of feed, deg. F. | 54.00 | 53.00 | 53.50 | 52.70 |
| Boiler pressure, by gage, lbs. | 129.40 | 127.20 | 127.20 | 129.10 |
| Quality of steam in dime | .982 | .981 | .984 | .983 |
| Evaporation.—Water evaporated per lb. of dry coal, lbs. | 6.94 | 6.60 | 6.30 | 5.58 |
| Equivalent evaporation from and at 212° F. | 8.26 | 7.87 | 7.52 | 6.67 |
| Horse-Power.—Boiler, HP. | 257.00 | 248.00 | 226.00 | 201.00 |
| Per sq. ft. of grate | 15.00 | 19.00 | 26.00 | 47.00 |
| Ratio heat developed in furnace to heat absorbed by water* | .61 | .59 | .56 | .50 |

*Approximate Efficiency.—The efficiency is approximate only, since the heating value of the coal is only approximately known. Since the same coal was used for all tests there can be no error in using this factor for purposes of comparison within the limits of the present series of tests.

the speed was varied slightly in different tests as a means by which desired rates of combustion might be the more readily secured, it was approximately 25 miles per hour for all tests. The running for each test, therefore, was equivalent to 150 miles.

As a rule, all important observations were checked by independent means. It is believed that these and other precautions taken were sufficient to insure accuracy in the observations recorded for the several tests.

Aside from their use as a means of checking other readings, the record of the Bristol recording gages was useful, also, in showing with what degree of constancy the desired conditions were maintained. In test No. 4, for which the rate of combustion was maximum, while the firing was difficult, the pressure did not often vary 5 lbs. from 130, which was the pressure desired.

As shown by the data obtained from frequent readings of a manometer attached to the smokebox, the normal draft for this test was equal to 5.6 ins. of water. The chart shows the maximum draft to have been 7 ins., and the minimum to have been about 3 ins. The results of the

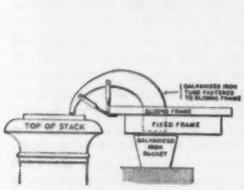



Fig. 5.—Apparatus for Collecting Samples of Sparks.

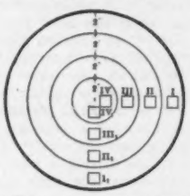


Fig. 6. Sections of Area of Top of Stack From Which Sparks Were Collected.

tests show that this draft of 5.6 ins. resulted in a rate of combustion of 241 lbs. per sq. ft. of grate per hour. It would at first appear impossible that so light a draft could produce so high a rate of combustion. The explanation is to be found in the fact that the effective area of the grate was small, the volume of furnace gases moved was much below normal for such a rate of combustion, and their velocity through the tubes was consequently low. The effect of the draft was, therefore, not greatly diminished by work done in the tubes, but was concentrated upon the fire, with the effect noted.

These recording gages were not used to supply the data used for the test, but the comparisons just described are sufficient to indicate the great value of self-recording apparatus, as a check against gross errors in readings taken from the more usual and more accurate instruments, and as a means of tracing the relations of cause and effect. It should be noted, also, that it is only since the advent of the laboratory that it has been possible to use such delicate instruments in locomotive work.

## LAYING WATER MAINS.*

By J. H. Decker, Deputy Water Purveyor, Brooklyn, N. Y.

One of the most important considerations (in pipe line construction) is the reduction to the minimum of the frictional resistance to flow of water. To this end the writer has all pipe of 12 ins. diameter and over enlarged at the joints, chamfering both at the spigot and hub ends of the pipe. This chamfer is for 12 to 30-in. pipes, 1¼ and ⅛-ins., and for 36 to 48-in., 1½ and 3-16-ins., respectively, the greater figures denoting measurements along the length and the lesser along the thickness of the pipe.

All loose rock and boulders should be removed from the trench; a rock surface should not be permitted to remain within 1 ft. of the pipe, except in cases where the trench is put through solid rock. In such cases the pipe should be raised clear of the rock surface with blocks of good sound timber and imbedded to a depth of at least 1 ft. from its upper surface in sand, loam or clay, which should be thoroughly tamped and rammed in about it. Whenever water should occur in a trench it should be drawn out and kept out until a firm foundation for the pipe shall have been obtained and until the joints have been properly calked. If the bottom should be soft or marshy, and liable to be insecure, it should be made safe and stable with masonry or concrete. In many cases it may be necessary to put in pile foundations for the pipe.

Each pipe, special, or gate of 24 ins. diameter and over should be laid upon two blocks firmly and evenly imbedded in the ground and should be adjusted to line and grade by means of wedges, which should be left in place. The blocks must be sound spruce or other good timber, as the locality may afford, and of a length equal to the diameter of the pipe. For 24 and 30-in. pipe the blocks should be 6 ins. wide and 6 ins. thick; for 36 to 42-in., 8 ins. wide and 6 ins. thick; for 48-in. and upwards, 8 × 8 ins. There should be for each block two wedges made from good sound 4-in. yellow pine or other equally good timber, sawn diagonally from end to end, and of length sufficient to cause the angle of the wedge to conform to the periphery of the pipe.

The spigots of the pipe should be so adjusted in the hub as to give a uniform space for lead all around. If from eccentricity of the hub or spigot, or from other cause, such space cannot be obtained, the defective pipe should be rejected. The width of this lead space should at all points be not less than ¼-in. for all pipes of 20 ins. diameter and under; not less than 5-16-in. for pipes 24 to 36 ins., and not less than ⅜-in. for pipes of 40 ins. and upwards. The depth of the lead in each joint should be, for 20 ins. and lesser diameters, 2 ins.; 24 to 36 ins., 2½ ins.; and for 40 ins. and greater diameters, 3 ins.

The gaskets should be of clean, sound hemp yarn, free from tar, braided or twisted and tightly drawn and should be driven firmly against the bead of the spigot and solidly calked up to the depth to receive the lead.

The lead should be of the best quality of pure soft metal, without admixture of any kind. No joint should be poured until the lead has been heated to a temperature of not less than 720° F. and all scoria has been removed.

Gates of 20 ins. or less diameter may be made with direct spindles and be set vertically, and should be covered with a good large iron gate box. All gates over 20 ins. should preferably be geared and set horizontally, and should also be provided with bypasses of suitable diameter. These should be set in good roomy brick vaults fitted with proper manholes with iron frames and covers.

On all trunk mains blow-offs of suitable size should be placed at all low points. At all high points air-cocks should be put in to free the main from any accumulation of air.

The writer is now in charge of the laying of about nine miles of 48-in. main for the city of Brooklyn. This is the third main of that size in the city, and with two lines of 36-in., comprises the trunk mains of the distribution system. In preparing his specifications he has embodied all of the foregoing points. All of the 30, 36 and 48-in. gates for this line are operated by hydraulic cylinders, which are guaranteed to open or close the gates against a pressure on the main, due to a head of 175 ft., with 25 lbs. pressure. The weight of these 48-in. gates is about twelve tons each; the average weight of the pipe, which is 1 5-16 ins. thick, 8,200 lbs. per length.

*Brief abstract of a paper read before the American Water-Works Association in May, 1896.

POLLUTION OF THE NAUGATUCK RIVER by the city of Waterbury, Conn., may be prevented by a court injunction. The hearing on the petition for the injunction is to be held at New Haven, Oct. 6.

MECHANICAL FILTERS, built by the New York Filter Mfg. Co., have just been put in service at Westerly, R. I. There are three 13-ft. wooden filter tanks with a combined capacity of 1,500,000 gallons per day.

A GREAT INTERCEPTING SEWER is to be put under contract at Cleveland, O., this fall. The sewer will be built along the valley of Walworth Run and will be 14,000 ft. in length. It will be 8 ft. in diameter at the head and 16 ft. 9 ins. diameter at the lower end. It will be of circular section and will be built of brick. The plans for the sewer were prepared by Mr. C. G. Force, M. Am. Soc. C. E. Besides the main sewer a large system of tributaries will be built, aggregating 32 miles in extent.

BIDS FOR GARBAGE COLLECTION AND DISPOSAL for the city of Brooklyn are called for by the Commissioner of City Works and are to be received until Oct. 5. The bidder must undertake the work from Jan. 1 next for a period of five years, and must agree to install some system that has been in successful use in this country for at least three months. The present garbage contractor of Brooklyn receives $129,000 a year.

A WATER POWER AND ELECTRIC PLANT is to be established at Chambly, Que., by the Chambly Water Power Co. There will be a concrete dam 28 ft. high and 1,100 ft. long across the Richelieu River, and the contract for turbines, etc., of 20,000 HP., has been given to the Stilwell-Bierce & Smith-Valle Co., of Dayton, O. The power house will be at the dam and the power will be transmitted to Montreal, a distance of 15 miles.

THE RENO INCLINED ELEVATOR has been installed experimentally at the old iron pier, Coney Island, at an expense of about $1,000, in order to illustrate the working of the device to officials of the Brooklyn Bridge and the elevated railways. This elevator was described and illustrated in our issue of Aug. 25, 1892.

SMOKE IS NOT A NUISANCE under some circumstances, according to a recent judicial opinion, and the verdict of a jury in Pittsburg, in a suit brought against the Terra Cotta Lumber Co. In his charge to the jury Judge Slagle said that the mills and works along the river and other places, from which smoke and noises issue, were essential to the existence of the community and that every person has a right to carry on a legitimate business, provided it is carried on as such business is usually conducted. Some businesses are a nuisance in themselves, "such as soap boiling establishments, lead works and many others," but these must be located in a spot not in the reach of persons. In a case like the one on trial, his honor said, and when the existence of the so-called nuisance is not necessarily injurious to the health, the surrounding circumstances must be taken into consideration to arrive at a determination, and it must be found that the immediate community is annoyed to convict. The jury accepted the opinion of the judge and returned a verdict of not guilty.

THE CASCADE LOCKS on the Columbia River, Oregon, are practically completed by the U. S. government and the first steamer passed through on Sept. 17. They will be formally opened for traffic on Nov. 15, after being more than 15 years under construction.

A CONNECTICUT WIDE-TIRE LAW went into effect on July 1, 1896, providing that all heavy vehicles made after that date and used upon the highways of that state should have tires from 2½ to 4 ins. wide, according to character. A penalty of $100 was fixed for any violation of this statute. There seems to be considerable opposition to this law and so far it does not seem to be enforced. Individually the wide tire is deemed advantageous; and the fact that the statute requires a departure from old practice appears to be the only reason for non-compliance with its terms.

AN INTERESTING CASE OF RIVER POLLUTION is reported from Indianapolis. The company which supplies that city with water some time ago obtained a perpetual injunction against the American Strawboard Co., prohibiting that concern from discharging into the White River the refuse from its mills at Noblesville. This concern thereupon built a huge reservoir for impounding its refuse by building an embankment across a low place in the river. Into this reservoir 3,000,000 gallons of refuse per day was discharged. The embankment finally broke and the refuse was swept into the stream. The court found the strawboard company guilty of negligence, fined it $250, for contempt, and declared the water company entitled to recover damages, the amount of which should be settled by a jury.

AERATION OF WATER IN A LONG SUPPLY MAIN is being practiced at Norfolk, Va., for the purpose of purifying the water and preventing growth of vegetable organisms.

THE HARRISBURG (PA.) FILTRATION COMMITTEE has reported that mechanical filters are better adapted to conditions there than sand filter beds; but advises postponement of action until the result of the Louisville tests are known and until financial conditions improve.

THE STRENGTH OF A BICYCLE FRAME is shown by the results of competitive tests recently made between steel frames made by E. C. Stearns & Co., of Syracuse, N. Y., and "luminum" frames, made by the St. Louis Refrigerator & Wooden Gutter Co. The steel frame was found superior in every kind of test. The following are the average results of the tests of the steel frames:

| | Crippling. | Ultimate. |
|---|---|---|
| Static load on crank hanger, lbs.... | 2,925 | 4,172 |
| " " on seat post, lbs. ..... | 4,275 | 5,438 |
| " " in line of sprockets, lbs.. ..... | | 2,600 |
| " " on pedal, one side, lbs. .. | 845 | 1,250 |
| Impact on seat post, inch-lbs..... | 13,300 | 15,900 |
| " " crank hanger, inch-lbs... | 8,678 | 9,857 |
| Horizontal impact on front fork.... | 3,544 | 4,463 |

STEAM PUMPS OPERATING WITHOUT OIL in their steam cylinders is a novel practice, adopted, for the first time, we believe, in the pumps furnished by The Geo. F. Blake Mfg. Co., of New York, for the new torpedo boats recently built by the Herreshoffs for the U. S. Navy. The pumps are constructed without any oil holes whatever, so that it is impossible for oil to get into the steam cylinders. They were given an exhaustive test for several days at the works, and they operated with entire satisfaction without using a drop of oil. The main engines of the boats will also be run without oil, but this is not a new idea with vertical engines. If the steam cylinders of both engines and pumps can be run successfully without oil, it will do away with the need for feed-water filters and with the danger of oil injuring the boilers.

A DEVICE FOR LOCATING SUNKEN WRECKS has been invented by a Baltimore man. It consists of a buoy to which is attached a long coil of rope, the whole loosely contained in a metal cage on the deck of the vessel. When the vessel sinks the buoy floats on the surface of the water, one end of the rope remaining fastened to the vessel. The buoy contains a bell which will be rung by the motion of the waves, and also a box in which may be deposited the story of the disaster which led to the sinking of the vessel.